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DDT AND WILDLIFE

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No chemical substance has excited greater general interest than DDT. This organic compound was first synthesized in 1874 by Zeidler in Germany, but its insecticidal properties were not reported until about 1940, by Paul Muller in Switzerland. The spread of World War II to all parts of the earth focussed the need for an effective chemical to control insects and other arthropods harmful to the health and well being of our armed forces. In consequence, an enormous amount of research was concentrated on DDT, and the effective results in its practical military use against mosquitoes, flies, and lice by the allies are already well known. Economic entomologists were quick to realize the potentialities of DDT for peace-time use against insects harmful to man, his crops, and his domestic animals. Even during the war period, they conducted wide series of investigations with this insecticide and many of the results have been spectacular. Already there is a large literature on the subject ranging from highly technical papers to popular notes. Use of DDT by agricultural industries, public health agencies, and others has been extensive since the end of warfare has made the material available. Administrators of public recreation areas such as beaches and parks have used DDT to reduce insect pests affecting human visitors to those places, and it has been employed in a few national, state, and other forests to lessen damage by insects affecting trees and shrubs.

Persons interested in wildlife quickly sensed that widespread applications of DDT to agricultural crops and over forests, marshes, and waters might affect animals other than insects in varying degree, both directly and indirectly. Lacking reliable information, wildlife workers, conservationists, nature lovers, and sportsmen could only speculate as to the possible bearing of widespread insect-control campaigns with DDT on the various kinds of vertebrates, from fish to mammals. Some poorly-informed popular writers have made fantastic claims that DDT would destroy all wildlife and that it actually had done so in certain applications. Such statements, based on conjecture or half-facts, may have far-reaching detrimental effects. Like many other materials used for control of animals prejudicial to human interests, DDT can be dangerous in the hands of careless operators, but of effective service when properly used by competent persons exercising the necessary precautions.

Most of the literature on DDT to date has dealt with insects and other arthropods; only a few papers have considered vertebrates and these have been mainly on the physiological, pharmacological, and histological effects of DDT administered experimentally to laboratory and domestic animals. For persons who wish to consult original papers dealing with DDT, some references are included herewith, including a bibliography and digest.

Studies by the U. S. Public Health Service on various laboratory and domestic mammals, and chickens have shown than DDT (1) is quite toxic, (2) its effect is cumulative, and its principal actions are on the central nervous system and liver. Use of DDT in aerosols and dusts, at the concentrations per unit volume of space recommended for insect control, have little hazard for man or laboratory animals. Inhalation or ingestion of massive doses by careless workers using these materials, may lead to toxic symptoms. Hence heavy contamination of food for man or animals should be avoided.

Through the cooperation of Dr. A. L. Nelson, Assistant Chief, Division of Wildlife Research, U. S. Fish and Wildlife Service, at the Patuxent Research Refuge, Bowie, Maryland, this issue of The Journal of Wildlife Management includes six papers giving results of direct field and laboratory studies on the effects of DDT upon wild vertebrates. These constitute a small but important contribution to the subject and should help to dispel some of the mistaken notions that have arisen. Other researches are in progress, and still others planned. When some of these latter have been completed and published there will be a better basis to evaluate the effects from use of this chemical in widespread applications, and to know the precautions necessary to protect neutral and beneficial species of animals of all types.

The data reported in the papers that follow show that DDT when employed in the lighter concentrations or rates of application per acre may exercise little or no effect on small mammals, and possibly none on birds. Heavy dosings over large areas will kill some birds and cause other to leave, presumably to seek food elsewhere. The character and rate of recovery of such populations is yet to be learned. Applications over waters containing fish result in some destruction of the latter, probably with unlike effects on different species; heavy contamination of water by oil slicks containing DDT may kill large numbers of fish.

Canadian workers found similar results in studies at Algonquin Park in Ontario; frogs and snakes were killed by moderate dosages in experimental trials. Several investigators have reported destruction of crayfishes (sometimes complete), especially in shallow waters. There are few data as yet for other invertebrates.

The amount and kind of disturbance to biological balances in nature following single or repeated applications of DDT is a matter of major interest on which there is imperative need for careful research and early publication of results.

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EFFECTS OF DDT ON FISH

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Early experiments in combatting insect pests indicated that uncontrolled use of DDT might be harmful to wildlife, especially fish. Both entomologists and wildlife biologists became concerned and realized that more exact information was required so that this chemical might be used to achieve desired ends with a minimum of damage. The U. S. Fish and Wildlife Service and the U. S. Bureau of Entomology and Plant Quarantine therefore undertook cooperative studies of the effects of DDT upon both fish and wildlife in the spring of 1945. Field experiments were on a scale sufficiently large to afford conclusions applicable to regular operational insect control, particularly in forest areas.

In the spraying of forests for control of spruce budworm and gypsy and brown-tail moths, the concentrations of

DDT used at first were as high as 5 and 3 pounds per acre. At these rates of application, fish and even birds were killed. By the end of 1945, the Division of Forest Insects had demonstrated that 1.0 pound of DDT per acre would probably be the maximum required for control of most forest insect pests. The effects of this concentration on the various species of fish therefore has been given special attention.

Experiments soon showed that 0.1 pound of DDT per acre was adequate to control breeding of malarial mosquitoes along the borders of marshes, reservoirs, ponds, and lakes. As for forest insects, the trend in the quantity of DDT needed for effective control is downward. Even 0.05 pound or less of DDT per acre may be effective for mosquitoes as spraying methods are improved. This small amount, however, has killed fish in small ponds after repeated treatments at weekly intervals, according to studies at the Carter Memorial Laboratory, Savannah, Georgia, by the U. S. Public Health Service.

DDT is a contact poison, paralyzing and killing insects that touch it. In both insects and fish it apparently affects the nervous system, but there is wide variation in the sensitivity of different species of fish to this chemical. M. M. Ellis, B. A. Westfall, and M. D. Ellis (Science, 100: 477, 1944) described hyperirritableness and subsequent muscular incoordination, muscular spasms, and finally marked prostration in goldfish following the intragastric administration of DDT dissolved in olive oil and incorporated in food pellets. After prostration, the fish lay on their sides, breathing irregularly, and sometimes making convulsive movements.

Field studies show that fish do not react as violently to DDT as to rotenone. Affected fish in small ponds usually approach the margins and often die with their snouts protruding from the water. In rotenone poisoning, as observed by the writer, affected fish came to the shore and often died up on the pond bank, completely out of the water. Following death from DDT poisoning, fish are usually found with opercular flaps extended as in suffocation.

To obtain uniform comparisons, all DDT solutions used in these studies (except the Ash Creek experiment and a corroborative experiment at Leetown) were prepared in the laboratory of the Division of Forest Insects at the Beltsville Research Center. Most of the field and laboratory studies used a 12 per cent DDT formula: 1 pound of DDT, 2 pints of xylene, and 2.65 quarts of fuel oil No. 2 per gallon.

FIELD STUDIES[1]

1. FOREST INSECT CONTROL AND WARM-WATER FISHES

On June 5, 1945, at the Patuxent Research Refuge, Bowie, Maryland, a 0.9 mile, deeply-wooded section of the Patuxent River was treated. This muddy stream, with a flow of about 130 cubic feet per second, was sprayed crossways of the stream by airplane with DDT, in xylene and fuel oil No. 2, at the rate of 2.0 pounds per acre. Ten hours after spraying, 95 dead fish (69% of the 138 dead fish recovered) were

[1] Francis M. Uhler aided in field work at the Patuxent Refuge.

removed from a stop net of 4 meshes per inch stretched across the stream at the lower end of the sprayed section within the Refuge. The principal species killed were the fallfish (*Leucosomis corporalis*), common shiner (*Notropis cornutus*), bluegill sunfish (*Lepomis machrochirus*), eastern madtom (*Schilboedes insignis*), and silverling minnow (*Notropis amoenus*). Fallfish and common shiners were affected before bluegill sunfish, large-mouth black bass (*Huro salmoides*), and eastern madtoms. Thus almost twice as many dead bluegills and four times as many dead madtoms were found at the stop net at 3 P.M. on June 6, as at 7 A.M. the same day. Fish drifted into the stop net for four days after spraying the river, but the greatest losses occurred within the first 48 hours.

Yearling bluegill sunfish, yellow perch (*Perca flavescens*), and red-bellied sunfish (*Lepomis auritus*) were placed in equal numbers (30 of each) in live boxes (60×26×26 inches) in the river above, within, and 1.5 miles below the sprayed area. Losses among penned bluegills within the sprayed area were heavy, the mortality being from 79 to 97 per cent; mortality among yellow perch in the sprayed area was small, varying from zero to 10 per cent. Red-bellied sunfish survived well except in a live box from which bluegills were omitted. In this box, only 35 per cent survived the treatment as compared with survival rates of 86, 93 and 86 per cent, respectively, in other live boxes in the sprayed area. The high mortality of 65 per cent in the one live box was attributed to lack of competition with bluegills which rose eagerly in the other live boxes to feed upon insects drifting on the surface. In feeding, they were exposed to the film of oil containing DDT.

Although seine hauls in the river before spraying revealed that the johnny darters (*Boleosoma nigrum*) and rosy-sided dace (*Clinostomus vandiosulus*) were more than twice as abundant as common shiners, the shiners were second in abundance among the fishes killed. The eastern redhorse sucker (*Moxostoma microlepidotum*), which fyke and trammel net collections showed to be common in the river, was apparently unaffected. No deaths occurred in the live box located 1.5 miles below the sprayed area.

Spray drifting about 150 feet from the sprayed area to a small gravel-pit pond was believed to have killed all golden shiners and pumpkin-seed sunfish there, but some bluegills, red-bellied sunfish, and yellow perch confined in a live box in the same pond survived in a manner indicating that feeding habits have much to do with mortality. In the live-boxes, the bluegills were most affected, apparently because they were bolder than other species and rose more frequently to the surface where they were exposed to DDT in the surface slick. Mortality began later and lasted longer in the gravel-pit pond than in the river.

2. FOREST INSECT-CONTROL AND COLD-WATER FISHES

A 3-mile section of Ash Creek near Clifton in Lackawanna County, Pennsylvania, was sprayed with DDT by airplane to determine the effect of forest spraying on cold-water fishes. Ash Creek is a soft water, slightly acid stream, and had a flow of 4,300 gallons per minute at the time of the experiment. The plane followed 19 windsocks

placed in tree tops along the stream during the application of DDT[2] at the rate of one pound per acre. Quantitative determination of the spray collected on filter papers[3] and glass plates at scattered points along the stream showed that an average of only about 0.23 pound of DDT per acre actually reached the water owing to the forest canopy, especially on the lower reaches of the stream.

Census by numerous seine hauls before spraying indicated a total brook trout population of 2,100 in the section. The stream also contained numbers of the common sucker (*Catostomus commersonii*), common shiner (*Notropis cornutus*), black-nosed dace (*Rhinichthys atratulus*), fallfish (*Leucosomus corporalis*), and golden shiner (*Notemigonus crysoleucas*), particularly in the lower mile of the sprayed section.

To intercept dead or dying fish, four weirs were placed at intervals across the stream and 2 live boxes above each weir. Brook trout were placed in one of each pair of live boxes and a miscellany of cold-water species in the other. On August 9, 1945, the stream was sprayed at 6:32 A.M. (EWT). The water surface was three-fourths covered with the oil slick at the lowest downstream weir by 6:33 A.M., but by 7:03 A.M. only strings of film remained except in the eddies. Wild trout in the creek rose to the surface for insects for only a short time, probably because large nymphs (*Stenonema, Isonychia, Perla,* and *Pteronarcys*) drifting along the bottom soon became so abundant that there was no need to rise for food. About 2 hours after the spraying, the rate at which insects were passing downstream was determined at a point 2 feet to the left of midstream at the fourth weir (surface velocity 0.95 foot per second). An estimated 61,000 insects (mostly winged) were passing down the stream hourly at the surface and 16,000 aquatic insects were drifting along the bottom.

It was expected that all brook trout in the live box at the lowest weir would die because their pen was in an eddy, the surface of which was completely covered with an oil film that persisted for 45 minutes (6:36 to 7:21 A.M.). Despite the film, trout were rising in the box at the rate of 6 times per 5-minute period to seize insects which drifted inside. Shortly after the film disappeared, the rises increased to 54 in a 5-minute period ending at 7:27 A.M. At noon, the trout were still feeding heavily, but the rate decreased sharply in the afternoon. In spite of this heavy exposure to DDT, only four of the 30 fingerling brook trout died in this live box.

Affected fish began drifting into the weirs about 12 hours after the spraying. The warm-water fishes—fallfish, common shiner, common sucker, and golden shiner—in the lower reaches of the stream were affected first. Most of the deaths occurred within 2 days after spraying. Brook and brown trout were affected more slowly; their losses and those among the common suckers extended over about one week. Of all observed fish losses, 69 per cent occurred within 34 hours after spraying. The 171 fish killed were as follows: 27 brook trout, 12 brown trout, 40

[2] Formula: DDT, 1.0 pound; xylene, 1 quart; kerosene, 3 quarts. Of this, 43 gallons were used in spraying the 3-mile length of stream.

[3] Analyses by U. S. Bureau of Entomology and Plant Quarantine, Insecticide Investigations.

common suckers, 2 black-nosed dace, 16 fallfish, 62 common shiners, 11 golden shiners, and 1 grass pickerel.

From sampling the native brook trout population before and after spraying, it was estimated that about 1.3 per cent of the brook trout population was killed by the application.

The warm-water fishes present chiefly in the lower reaches of the stream were seriously affected, but less than half of them were estimated to have been killed.

In live-boxes stocked with 30 brook trout each, the maximum loss was 4 fish in the weir farthest downstream. The average loss of brook trout in live-boxes was 6 per cent. Other live-boxes were stocked with equal numbers of miscellaneous cold-water fishes, including the sculpin (*Cottus cognatus*), black-nosed dace, creek chub (*Semotilus atromaculatus*), pearl minnow (*Margariscus margarita*), top minnow (*Fundulus diaphanus*), and common sucker, but only 4 in a total of 203 were lost between August 9 and 15, 1945.

3. POND EXPERIMENT WITH TROUT AND SUNFISH

Four ponds, each 125 by 8 by 2 feet, and supplied with 109 gallons of hard spring water per minute at Leetown, West Virginia, were stocked with 100 brook trout, 100 rainbow trout, and 100 bluegill sunfish each. Ponds Nos. 1 and 4 in this series also were stocked with golden shiners. The water flowed from one pond into the next.

The trout were 5 to 7 inches in length, the bluegill sunfish 3.5 inches long, and the golden shiners from 3.5 to 5 inches in length.

The ponds were sprayed within an 8-minute period beginning at 9:29 A.M. on August 18, 1945, with the DDT-xylene-kerosene formula used in the Ash Creek experiment at 1.0 pound of DDT per acre. Oil spray remained visible on the surfaces of these ponds until 1:50 P.M.

Rises of fish to the surface during a 5-minute period were counted at 10:15 A.M., when the ponds were completely covered with oil films, with results as follows: Pond No. 1, 54; No. 2, 37; No. 3, 175; No. 4, 61 rises. Rises again were enumerated from 11:35–11:40 A.M., when the counts were 105, 83, 108, 3, and 55, respectively. A few dead or paralyzed insects were found on the water surface, but the rises by the trout seemed to be principally in sport or to gulp air.

Brook and rainbow trout were completely unaffected by the treatment, but from 4 to 12 per cent of the bluegill sunfish were killed. None of the golden shiners in Pond No. 2 was killed, but 20 per cent of those in Pond No. 4, the last in the series, were killed. These losses occurred by August 23 and there was no further loss until September 12, when the experiment was concluded.

4. WARM-WATER FISHES IN SOFT-WATER PONDS

Eight soft-water ponds at the Patuxent Research Refuge, each with a surface of 1,000 square feet, were stocked on May 8, 1945; each received 30 large fingerling bluegill sunfish, 15 red-bellied sunfish, 14 yellow perch, and 3 adult crappies. On May 9 the ponds were sprayed with DDT in oil at the following rates per acre: Three with 0.1 pound, two with 0.5 pound, two with 1.0, and the eighth pond left unsprayed as a control. No mortality was observed in 2 of the 3 ponds treated at 0.1 pound per acre, but

severe losses occurred in ponds receiving 0.5 and 1.0 pound per acre. Losses observed by walking around the latter ponds ranged from 7 to 40 per cent in bluegills, zero to 53 per cent in red-bellied sunfish, zero to 7 in yellow perch, and 33 to 100 per cent in adult crappies. Observed losses were greater in the 0.5 pound-per-acre ponds than in the 1.0 pound-per-acre ponds. When several ponds were pumped dry, however, actual losses proved much greater than the observed losses; the greater observed losses in the 0.5-pound ponds were apparent and not real.

5. WARM-WATER FISHES IN HARD-WATER PONDS

Each of 12 small hard-water ponds at Leetown, West Virginia, was stocked on October 2, 1945, with 50 bluegill sunfish (*Lepomis macrochirus*) averaging 3.6 inches and 50 largemouth bass (*Huro salmoides*) averaging 4.9 inches in length.

These ponds, except for 3 control ponds, were sprayed with the following solutions to apply 1.0 pound of DDT per acre so that each experiment had three replications:

Fuel oil formula (1 gallon)	
DDT	454 grams
Xylene	946 cc.
Fuel oil No. 2	2,575 cc.

Emulsion formula (1 gallon)		
DDT	454	grams
Xylene	1,183	cc.
Polyethylene glycol 400 monooleate	59	cc.
Water	2,255	cc.

Suspension formula (0.5 gallon)		
Deenol powder	454	grams
Water, to make	0.5	gallon

The Deenol powder consisted of equal parts of DDT and Fuller's earth.

The sprays were applied from a canoe by use of a continuous-pressure hand sprayer. The canoe was controlled during the spraying by ropes in the hands of men on the bank and a uniform application of spray was obtained.

The ponds were treated on October 24, 1945, when a period of dead-calm, cloudy, and warm weather provided ideal conditions. After application, the suspension and emulsion materials entered the water immediately although films of these materials also spread and covered the surfaces of the ponds. The fuel oil spray remained on the surface without disturbance by air currents from about 1:15 P.M., October 24 until 12:20 A.M., October 25.

Past experience had shown that most affected fish died within 2 or 3 days after spraying, and that little reliance could be placed on observed mortality since predators removed part of the evidence. Consequently these ponds were drained November 1, after one week, and the actual survival determined by counting the fish that survived the treatments.

The ponds were first revisited at 7:15 A.M., October 25, about 18 hours after spraying. In the fuel oil ponds, bluegill sunfish were dying, but few were dead. Fish in the emulsion-sprayed ponds were already dead, whereas those in the control and suspension-DDT ponds apparently were unaffected. Mortality apparently ceased in the ponds by the evening of the second day (October 25).

The emulsion formula (polyethylene glycol 400 monooleate as emulsifier) killed all fish. DDT in xylene and fuel oil No. 2 killed 50 to 60 per cent of fingerling bluegill sunfish, but had little effect on fingerling largemouth bass.

The aqueous suspension of DDT and Fuller's earth in a commercial product did not kill bass, but 25 bluegills were killed in one pond and 1 bluegill in another.

All of the fish placed in two control ponds were recovered, but only 76 per cent of the bass were found in the third pond where all bluegills survived.

On September 8, 1945, two small ponds at Leetown stocked with 50 smallmouth bass (average length 94 mm.), 50 bluegill sunfish (average length 101 mm. and 94 mm., respectively), were sprayed with DDT in xylene and fuel oil No. 2 at 1.0 pound per acre. When these ponds were drained on September 21 and 25, 54 and 44 per cent of the smallmouth bass, 76 and 92 per cent of the bluegill sunfish, and 58 and 56 per cent of the golden shiners, respectively, were recovered. This experiment indicated that smallmouth bass and golden shiners are more sensitive to DDT than bluegill sunfish.

A pond 0.35 acre in area containing 20 adult largemouth bass and 40 adult bluegills was sprayed with DDT in kerosene at 1 pound per acre on September 13, and again on September 20, without loss of a fish.

LABORATORY STUDIES

EFFECTS OF DIFFERENT CARRIERS AND OF TREATED INSECTS[4]

In these experiments with spray and DDT-treated insects, the general procedures were as follows: common house flies (*Musca domestica*) and their larvae, reared in artificial manure, were fed to bluegill sunfish and largemouth bass after treatment at the rate of 1.0 pound of DDT per acre in a 0.1 milliacre chamber. The insects were inactivated in a refrigerator or anaesthetized with carbon tetrachloride before spraying, and were fed to the fish while still alive. Calculations of the maximum possible amount of DDT present, if it were soluble or completely emulsified in the aquaria sprayed at 1.0 pound per acre, indicated a rate of about 0.5 p.p.m.

These experiments were conducted in duplicate, in aquaria with a water depth of 8 inches; 4 bluegill sunfish or largemouth blackbass (average length 62 to 92 mm.) were placed in each container. Two controls were used in this series: one remained untreated and the other received the amount of xylene and fuel oil No. 2 (without DDT) that they would receive in a 1.0 pound per acre treatment. Untreated flies and larvae were fed to fish in the control aquaria, and no losses occurred.

Four aquaria in which the bluegills remained unfed, were treated with DDT in oil carriers at 1.0 pound per acre: two receiving kerosene as the carrier, and two the fuel oil No. 2. The fish died within 35 to 83 hours, in those receiving kerosene. In one fuel oil experiment, all fish were dead in 17 hours, but all survived for some inexplicable reason in the second fuel oil experiment.

Two aquaria were sprayed at the 1.0 pound rate with DDT in fuel oil No. 2. Treated flies were fed with the result that all bluegills died in 22 to 58 hours.

Four largemouth bass (60–67 mm.) were placed in each of 6 Fearnow pails, the water surfaces of which remained untreated. House-fly larvae treated at the 1.0 pound per acre rate with DDT in the fuel oil formula were fed to the

[4] Dr. C. H. Hoffmann, Dr. F. C. Craighead, and Mr. W. R. Walton cooperated in this study.

bass in four pails; all in two pails were killed in 20 to 97 hours and three of four in the other pails. No fish died in the controls until after 6 days.

On the day after feeding, the affected bass which had not yet died were highly excitable, and a nervous quivering reaction characteristic of DDT poisoning in both bass and bluegills followed visits to the pails.

When kerosene was used as the carrier in an experiment with bluegills in aquaria where untreated flies were fed, the bluegills died in 16 to 42 hours.

Flies treated at 1.0 pound per acre with 12 per cent DDT in xylene and fuel oil No. 2, were fed to bluegills in aquaria in which the water surface remained unsprayed. No fish were lost.

In a similar experiment in two concrete daphnia ponds each stocked with 25 fingerling bluegills (3.0 to 3.5 inches long) and 25 adult bluegills (6 to 7 inches long), 3,988, and 4,037 treated flies, respectively, were fed in the two ponds over a period of 3 days. The fish were observed for 18 days (Sept. 11 to 28, 1945), during which time none was lost in either the experimental lot or in a control lot of fish in a daphnia pond nearby that received untreated flies.

A DDT emulsion formula[5] was quickly lethal to bluegills. In two aquaria each stocked with 4 bluegills and sprayed with the emulsion formula all fish died in 3.3 to 9.6 hours. In a second series of experiments in which it was planned to combine surface treatment with emulsion-treated flies, the fish became sick and died in from 3.8 to 5.9 hours without consuming a single treated insect.

When emulsion-treated housefly larvae were fed to bluegills in aquaria in which the surfaces remained unsprayed, no fish were killed.

[5] Twelve per cent emulsion formula: DDT, 454 grams; xylene, 1,183 cc.; L-34 emulsifier (polyethlene 400 monooleate), 59 cc.; water 2,255 cc.

SUMMARY

A study of the effects of DDT on fish was conducted by the U. S. Fish and Wildlife Service in collaboration with the U. S. Bureau of Entomology and Plant Quarantine. Since the rates of application required for control of forest insects are considerably higher than for malarial mosquitoes in open marshy areas, special attention was given to effects of the highest rate (1.0 pound DDT per acre) apparently required for control of forest insect pests.

A 117 acre-tract of bottom woodlands in the Patuxent River, Maryland, was sprayed by plane at the rate of 2.0 pounds DDT per acre; 139 fish were found dead in the 0.9 section of river within the sprayed area. Fallfish, common shiners, and other minnows were affected before bluegills, bass, and eastern madtoms. Sixty-nine per cent of all dead fish were found 9.5 hours after the spraying, but dead fish drifted into the stop net for 4 days after treatment. In live-boxes stocked with equal numbers of yearling bluegills, redbellied sunfish, and yellow perch, 79 to 97 per cent of the bluegills were killed, but mortality in yellow perch did not exceed 10 per cent in any box.

In Ash Creek, Pennsylvania, 3 miles of a rich trout stream were sprayed by plane at the rate of 1.0 pound DDT per acre, with an estimated loss of 1.3 per cent of the brook trout population. In

all, 171 fish of all species were killed. Affected fish began drifting into the screen weirs (across the stream) about 12 hours after spraying. Fallfish, common shiners, common suckers, and golden shiners in the stream were affected before the trout. Black-nosed dace were abundant, but few were affected. In a live-box at the last weir downstream, 30 brook trout fed heavily for several hours on insects paralyzed by DDT with the loss of only 4 of their original number.

In an experiment in 4 trout raceways in series at Leetown, West Virginia, 100 each of brook and rainbow trout, and of bluegill sunfish in each pond were exposed to a 1.0 pound per acre treatment without the loss of a single trout; but 4 to 12 per cent of bluegill sunfish were killed.

Twelve small hard-water ponds at Leetown, West Virginia, were each stocked with 50 large fingerling bluegills and 50 fingerling largemouth bass. Nine ponds were sprayed at 1.0 pound DDT per acre in three different carriers, each experiment having 3 replications. In ponds treated with DDT in xylene and fuel oil, 50 to 60 per cent of the bluegills were killed, but few bass were lost. In ponds where the DDT was administered in an emulsion, all fish were killed. In the third series, a suspension of DDT with Fuller's earth killed only a few fish in one of three ponds.

Houseflies and their larvae sprayed at the rate of 1.0 pound DDT per acre failed to kill bluegills when fed to them, but largemouth bass were killed in one experiment.

Bluegills were killed somewhat earlier in aquaria with flies on the surface than in aquaria with oil sprays alone.

DDT in an emulsion formula applied to the surfaces of aquaria killed bluegills within 3 to 10 hours as compared with 35 to 83 hours for DDT in the oil carriers.

In these studies, fallfish, common suckers, common shiners, and golden shiners proved more sensitive to DDT poisoning than did brook trout, blacknosed dace, bluegill sunfish, largemouth bass, and yellow perch.

Smallmouth bass and bluegill sunfish are more sensitive to DDT than largemouth bass. Golden shiners and smallmouth bass are more sensitive than bluegills which, in turn, are more sensitive than brook trout and rainbow trout.

EFFECTS OF DDT SPRAY ON EGGS AND NESTLINGS OF BIRDS

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This experiment was made to determine whether DDT applied at the rate of 5 pounds per acre on bird nests would have any effect on the hatching of eggs, the development of young, or the abandonment of nests. The 5-pound rate was selected because at the time the work was being planned this dosage was considered the maximum likely to be used in operational control for insect pests of forests. Subsequent research has shown that most species of forest insects can be controlled by applications of 1 pound or less per acre.

The study was conducted during the spring and summer of 1945 at the Patuxent Research Refuge, and had two principal phases, application of DDT to nests with eggs and to nests with nestlings. All treatments were made in the same manner. The spray—1 pound of DDT in 2 pints of xylene diluted with fuel oil to make 1 gallon—was applied by a hand atomizer, 0.4 cc. being sprayed over an area of 1 square foot surrounding and including each nest. Daily observations of nests were made when possible.

Nests with Eggs

Thirty-four nests with eggs were studied, 17 treated and 17 as checks. Attempts were made to use the same number of each species. Only one set of starling eggs was available, in a bird box; a clutch of bluebird eggs in a bird box therefore was used as a check against the starling nest.

Table 1 shows that 41 of the 66 treated eggs hatched, a minimum hatch of 62 per cent. It is conceivable that between the last observation of a nest and the time a predator removed its contents some recorded as eggs at the latest observation had hatched. This undoubtedly was true of a field sparrow nest which contained four eggs, two of which were hatching, and the following day was empty.

Of the 64 check eggs, 38 hatched, or a minimum of 59 per cent. The rate of hatch for the DDT-treated eggs exceeded that of the check eggs by only 3 per cent. This slight difference is insignificant, as the sample was small; the difference could be due to chance or to uncertainties as with the field sparrow nest.

Since abandonment is one possible result of DDT treatment, two mockingbird nests should be considered. Eight mockingbird eggs were abandoned (Table 1), 4 in a treated nest and 4 in an untreated nest. A check of nest records in the Refuge files showed four other mockingbird nests abandoned (not used as subjects in this experiment). Abandoning the treated nest cannot necessarily be attributed to the treatment, but more likely to the readiness of mockingbirds when disturbed to abandon nests with eggs. Additional evidence against abandonment being due to the treatment is

TABLE 1.—EGG HATCHABILITY IN RELATION TO DDT SPRAYING.

Species	*Nests used*	*Eggs per species*		*Eggs hatched*		*Reason unhatched*	
		Treated	*Checks*	*Treated*	*Checks*	*Treated*	*Checks*
Mourning dove	2	2	2	2	2	—	—
Eastern phoebe	2	3	6	1	5	2 sterile	1 sterile
Barn swallow	2	4	3	3	3	1 sterile	—
House wren	2	7	7	7	5	—	2 sterile
Mockingbird	6	10	12	5	3	1 sterile 4 abandoned	1 sterile 4 abandoned 4 storm
Catbird	2	4	5	0	4	4 predation	1 sterile
Robin	6	12	9	7	5	4 predation 1 sterile	4 predation
Eastern bluebird	3	4	7	4	3	—	4 predation
Starling	1	6	—	5	—	1 sterile	—
Chipping sparrow	4	6	6	2	2	4 storm	3 storm 1 sterile
Field sparrow	4	8	7	5	6	2 predation 1 sterile	1 sterile
Totals	34	66	64	41	38		
Percentage hatch				*62*	*59*		

supported by the hatching of 5 sprayed eggs in two other mockingbird nests.

For reasons other than storm and predation, 7 of the 66 treated eggs (11%) failed to hatch, but this failure cannot be attributed to the DDT treatment because 7 of 64 untreated eggs (also 11%) did not hatch. Sterility and faulty incubation (both termed sterility here), are common with birds, and are undoubtedly responsible for the failure of the eggs to hatch.

NESTS WITH NESTLINGS

Nineteen nests were used to treat young birds, and 19 others served as checks. When possible, the same number of nests of each species was used. The information in Table 2 is quite misleading, by indicating a survival of 62 of 65 treated young, and 56 of 60 among the checks (95% in each). The records obtained do not measure nestling survival, since many of the nests were not discovered until the young were

TABLE 2.—SURVIVAL OF NESTLINGS IN RELATION TO DDT SPRAYING.

Species	*Nests used*	*Nestlings per species*		*Nestlings survived*		*Nestlings lost*		*Cause of loss*
		Treated	*Checks*	*Treated*	*Checks*	*Treated*	*Checks*	
Mourning dove	2	2	2	2	1	0	1	Unknown
Eastern kingbird	2	4	3	3	3	1	0	Unknown
Eastern phoebe	2	4	5	4	5	0	0	—
House wren	2	7	6	7	6	0	0	—
Brown thrasher	2	3	3	3	3	0	0	—
Robin	8	13	8	11	5	2	3	5 predation
Eastern bluebird	4	9	10	9	10	0	0	—
Starling	1	5	—	5	—	0	0	—
Prairie warbler	2	3	3	3	3	0	0	—
Chipping sparrow	10	11	12	11	12	0	0	—
Field sparrow	2	4	4	4?	4	0?	0	—
Song sparrow	1	—	4	—	4	0	0	—
Totals	38	65	60	62	56	3	4	
Percentage survival				*95*	*95*			

more than half grown, which means that there were other nests in the area of which the broods fell victims to various tragedies. The young found were among those that had escaped until that time and had only a short period of nest life yet to experience. Furthermore, daily visits by the observer to nests, and brief removal of young for bird banding, in the few cases that banding was delayed, was disturbing and would cause the young to depart sooner than they ordinarily would have done. The period of time these birds were under observation was shorter, therefore, than that to which they normally would be exposed.

There is still a third reason why the figures are misleading. When the birds had grown to such a stage that they possibly would leave in a day or so, and when on that next day the nest was found to be empty their fate was unknown unless they were observed in the vicinity. A predator might have killed them just prior to departure. In such cases survival of the brood was given the benefit of the doubt over predation.

Three days after four well-grown kingbirds had been sprayed the young were observed in the nest. On the following day it appeared as though the brood had departed, but a closer check three days later revealed one dead in the nest. It is doubtful that this death could be attributed to the DDT, because the same fate did not befall the rest of the brood. A similar incident occurred with an unsprayed brown thrasher nest not included in this experiment, being too distant to make daily observations. Four young appeared ready to fly and on the following day three were seen in the vicinity and the fourth was found dead in the nest. Such an event could occur naturally and be a fatality from some cause other than DDT.

Four days after two newly-hatched robins had been sprayed they vanished from the nest. Until then, they seemed perfectly normal. They were probably the victims of predation. Seventeen other birds, also newly hatched, were not affected by the spray treatment.

Among the nests treated were seven of eastern bluebird, four of house wren, and two of starling, all in boxes. There was no mortality save for one case of predation on bluebird eggs. No nests were abandoned with either young or eggs. Two barn swallow nests and one of eastern phoebe, all containing eggs in somewhat confined quarters, were treated and none was deserted.

SUMMARY

Thirty-four nests of 11 species of birds containing eggs, and 38 nests of 12 species containing young of various ages, were used to determine the effect of applying DDT spray. Seventeen of the nests containing eggs and 19 of those containing young were left unsprayed as checks. The spray consisted of 1 pound of DDT to 2 pints of xylene diluted in fuel oil to make 1 gallon, and was applied by a hand atomizer over an area of 1 square foot surrounding and including each nest, at a dosage equivalent to 5 pounds of DDT per acre. This treatment evidently had no detrimental effect upon the hatching of eggs or development of young; it was not observed to cause abandonment of nests even when located in confined quarters.

EFFECTS OF DDT ON BIRDS AT THE PATUXENT RESEARCH REFUGE

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An experimental aerial application of DDT at 2 pounds per acre was made on a 117-acre tract (Fig. 1) within the Patuxent Research Refuge on June 5, 1945, in cooperation with the Division of Forest Insects, U. S. Bureau of Entomology and Plant Quarantine. The spraying was arranged for by that Division through Dr. F. C. Craighead. The chief objective of the test was to determine the effects of such an application on wildlife.

The DDT was sprayed as an oil solution from an N-3N Navy trainer airplane, using a tank equipped with a gear pump which metered the DDT solution into a hollow pipe provided with spray nozzles. The pipe was attached beneath and extending the length of the lower wing. The solution comprised 1 pound of DDT, 2 pints of xylene, and 5.7 pints of No. 2 fuel oil; and an effort was made to apply 2 gallons to each acre of land. This spray was applied within a few feet of the top of the forest canopy on a relatively quiet evening. Observers in the vicinity of the study area at the time of spraying reported considerable loss of spray by drift of fine oil particles.

The sprayed area was within the well-drained bottomland forest type, which was selected as that most likely to yield the most reliable results because of its dense breeding bird population. Three study areas (Fig. 1, Nos. 1, 2, 3), all within this type, were studied intensively during May and June. Area No. 1, of 31 acres, was within the sprayed region, Area No. 2, of 32 acres used as a check, was 1⅛ miles from the sprayed region, and Area No. 3, of 22 acres, also used as a check, was immediately adjacent to the sprayed region. The principal reason for studying Area No. 3 was to determine if there was any marked influx of birds into the areas surrounding the sprayed region due to the application of the spray. Area No. 3 was ideally situated for this purpose since the bottomland forest type "funnels" through it from the sprayed region so that any general movement of birds could be discerned readily.

The bottomland forest on the Refuge covers the well-drained portion of the flood plain of the Patuxent River, and is characterized by a great variety of plants. The dominant trees include: river birch (*Betula nigra*), hornbeam (*Carpinus caroliniana*), beech (*Fagus grandifolia*), pin oak (*Quercus palustris*), American elm (*Ulmus americana*), tulip poplar (*Liriodendron tulipifera*), sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), and white ash (*Fraxinus americana*). The dominant shrubs and woody vines include poison ivy (*Toxicodendron radicans*), blackhaw (*Viburnum prunifolium*), and spicebush (*Lindera aestivalis*). The dominant herbaceous plants include jack-in-the-pulpit

(*Arisaema triphyllum*), yellow adder's tongue (*Erythronium americanum*), wood nettle (*Laportea canadensis*), springbeauty (*Claytonia virginica*), may-apple (*Podophyllum peltatum*), touch-me-not (*Impatiens biflora*), violet (*Viola*

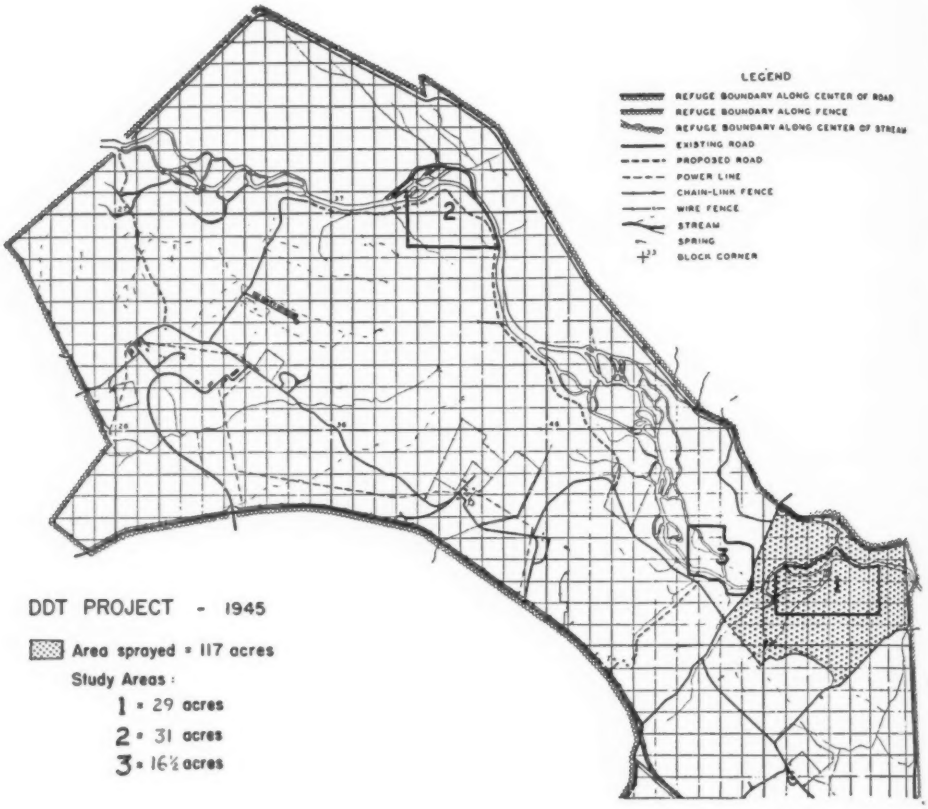

Fig. 1. Map of northern part of Patuxent Research Refuge, showing areas studied in DDT application.

affinis), enchanter's nightshade (*Circaea latifolia*), honewort (*Cryptotaenia canadensis*), and cleavers (*Galium aparine*).

The amount of DDT reaching the ground through the forest canopy naturally was much less than that distributed. To determine the quantity of residue, 4-inch petri dishes were distributed throughout the area before the spraying. Eighteen plates were placed along the riverbanks, which are more or less overhung by the tree canopy, but the most exposed sites in the area, except for the river itself. The DDT deposition there averaged 0.6 (0.004 to 1.44) pounds per acre. The 18 plates placed on open forest floor beneath tree canopy only, averaged

0.05 (0.002 to 0.21) pound per acre, and on 42 plates under the tree canopy and also under ground cover of various types (weeds, grass, shrubs), the DDT averaged only 0.008 (0.0008 to 0.06) pound per acre.

A detailed study of the insect populations before and after spraying on study areas Nos. 1 and 2 was made by the U. S. Bureau of Entomology and Plant Quarantine. On the sprayed area, many insects were killed within a few days after the treatment. The temporary elimination of adult pest mosquitoes was especially outstanding. For most species of insects, however, the effects were not prolonged, as most of them seemingly were present in normal numbers 2 or 3 weeks later.

Determinations of the adult breeding bird populations were made on all three study areas before and after the spraying, by numerous strip censuses in the early morning hours up to 10:00 A.M. The exact location of each bird was plotted on field maps so that after repeated censuses it was possible to outline with fair accuracy the territory of each breeding pair on the three areas. Then it was necessary only to count the territories to determine the actual numbers of breeding pairs of each species. Comparing the numbers of breeding birds in Area No. 1 with those in Areas Nos. 2 and 3 before and after spraying, indicated the effect of DDT on the bird populations.

During May, and until the date of spraying, an intensive search was made for nests in Areas Nos. 1 and 2. Detailed records were made of all nests, and, each was visited daily until the young had departed or until the nest was deserted or destroyed. These records served to determine the effect of DDT on nesting success by comparing the mortality rates of eggs and young in the sprayed and unsprayed areas.

BIRD POPULATIONS

The density of breeding birds of all species for the bottomland forest type was about 390.5 pairs per 100 acres, as determined by the data from all three study areas. The density of Area No. 1 was 415 pairs per 100 acres, and on Areas Nos. 2 and 3, 374 pairs per 100 acres. The average density for each species in the bottomland forest type as a whole is indicated in Table 1.

TABLE 1.—DENSITY OF ADULT BREEDING BIRDS IN BOTTOMLAND FOREST, PATUXENT RESEARCH REFUGE, MAY 1945.

	Pairs per 100 acres
Red-eyed vireo	92.0
Redstart	51.0
Parula warbler	47.2
Acadian flycatcher	39.2
Wood thrush	23.6
Kentucky warbler	23.0
Scarlet tanager	18.5
Ruby-throated hummingbird	15.3
Cardinal	13.0
Tufted titmouse	12.9
Red-bellied woodpecker	7.1
Downy woodpecker	5.7
Carolina wren	5.6
Carolina chickadee	5.1
Blue jay	5.0
Louisiana water-thrush	4.1
Yellow-throated vireo	3.4
Yellow-billed cuckoo	3.0
Maryland yellow-throat	2.4
Hairy woodpecker	1.8
Blue-gray gnatcatcher	1.7
Wood duck	1.2
Mourning dove	1.2
Crested flycatcher	1.2
Wood pewee	1.2
Barred owl	0.7
Red-shouldered hawk	0.4
Turkey vulture	0.4
Prothonotary warbler	0.4
Crow	0.2
Pileated woodpecker	0.2
Phoebe	0.2

The data on the population densities of the wide ranging or rarer species, including the last 7 species in the list, were derived from special studies made on the Refuge during previous years. The presence of phoebes within the bottomland forest on the Refuge was undoubtedly because of a bridge there.

Comparison of the numbers of breeding birds present before spraying and those present several days after spraying, showed a decrease of 11.9 per cent on the sprayed Area No. 1; a drop of 5.3 per cent on check Area No. 2, and of 9.7 per cent on check Area No. 3. The greatest decrease occurred on the sprayed area, but probably was not significantly different. By repeated censuses, the population trends in the three areas were studied for several weeks after spraying and no marked differences were noticed between them.

Apparently there was no outward movement of birds from the sprayed

TABLE 2.—PAIRS OF BIRDS IN STUDY AREAS IMMEDIATELY BEFORE AND SEVERAL DAYS AFTER SPRAYING WITH DDT.

	Sprayed				*Not sprayed*	
	Area No. 1 (31 acres)		*Area No. 2 (32 acres)*		*Area No. 3 (22 acres)*	
	Before	*After*	*Before*	*After*	*Before*	*After*
Wood duck	1	0				
Mourning dove					1	1
Yellow-billed cuckoo			3	1		
Ruby-throated hummingbird	7	6	4	4	2	1
Red-bellied woodpecker	4	3	3	3	1	1
Hairy woodpecker	1	1	1	1	1	1
Downy woodpecker	3	3	3	3	2	2
Crested flycatcher			2	2		
Phoebe					1	1
Acadian flycatcher	21	21	12	12	8	8
Wood pewee					1	1
Blue jay	1	1	3	1	1	1
Carolina chickadee	5	4	5	5	1	1
Tufted titmouse	7	7	6	6	2	2
Carolina wren	4	3	3	2	2	2
Wood thrush	4	4	15	14	7	7
Blue-gray gnatcatcher					1	1
Yellow-throated vireo	3	3	1	1	2	2
Red-eyed vireo	36	32	38	36	19	17
Parula warbler	23	22	16	16	8	8
Ovenbird[a]	4	2	1	1		
Louisiana water-thrush	4	2			2	2
Kentucky warbler	9	9	10	10	6	6
Maryland yellow-throat					2	2
Hooded warbler[a]	3	3	1	1		
American redstart	19	13	13	13	15	10
Scarlet tanager	13	12	6	6	2	2
Cardinal	5	5	4	4	6	5
Totals	177	156	150	142	93	84

[a] In small areas of terrace forest (beech-white oak) within study area, but not in bottomland type.

area, as there were no appreciable "jumps" in the number of birds on check Area No. 3 at any time. A few young of the downy woodpecker, Carolina chickadee, and Kentucky warbler were color-banded in nests within the sprayed area (No. 1) and these birds remained in that area after leaving their nests, throughout the time that the study continued.

After spraying, the numbers in most species either remained the same or decreased slightly (Table 2). Where a decrease occurred, the rate of decrease for any one species was fairly constant on all three areas, but the redstart was an exception. Its decrease was marked in Areas Nos. 1 and 3, while in Area No. 2 the numbers remained the same.

The redstart is one of the first passerines to stop singing and cease nesting activities in this region; hence decreases observed may have been due to natural causes as it was about the same on one check area as on the sprayed area. When population trends were studied in more detail (day by day) in the study areas, however, differences between the sprayed and check areas became more disproportionate, indicating that the redstarts probably had been affected somewhat by DDT (Table 3).

TABLE 3.—PAIRS OF AMERICAN REDSTARTS IN STUDY AREAS.

	No. 1 sprayed	*No. 2 unsprayed*	*No. 3 unsprayed*
Week preceding June 5 (date of spraying)	19	13	15
June 7 and 8	11	12	10
June 9–13	7	9	8
June 19–30	3	8	10

There was a more abrupt drop in numbers in the sprayed than in the check areas. The slight increase of numbers in Area No. 3 during the last period probably was due to wandering birds that had finished nesting for the season. Area No. 3 is a more favorable habitat for redstarts than Areas Nos. 1 or 2, henced probably attracted more non-nesting birds. Population data for other species, examined in the same fashion, showed no corresponding discrepancy in rate of decrease between sprayed and unsprayed areas.

Other evidence that redstarts were affected by DDT includes one observation of a male redstart in the sprayed area on June 8 affected by nervous tremors and lack of coordination in movement, both characteristic symptoms of DDT poisoning. On the same day in another part of the sprayed area a nest containing four young redstarts was visited at 4:30 P.M.; all of the young were dead and cold, and the parents not in evidence; at 8:40 A.M. the young had been alive and noisy. No adult redstart was seen in either of these territories on later censuses.

The feeding habits of some species were changed somewhat by the DDT application, especially during the three days after spraying. Dead and dying insects then were common on or near the ground, and several species of birds that ordinarily feed at higher levels were on the ground or in dense patches of herbs, busily feeding on the abundant fallen prey. Red-eyed vireos and redstarts fed in this fashion more commonly than other species.

NESTING MORTALITY

Comparison of the number of nests

active at the time of spraying (7:00 P.M., June 5) and the number in which young were fledged successfully (Table 4) shows that nesting was less successful in the sprayed than the unsprayed area. The discrepancy between the percentages of successful nests in the two areas resulted largely from high losses by predation of Acadian flycatcher nests in the sprayed area. Moreover in accounting for each individual egg and nestling, it becomes apparent that in every case of mortality, with one possible exception, some normally operating factor was responsible, and not DDT.

EGG MORTALITY

Analysis of the known causes of mortality shows that of 67 eggs laid in the sprayed area, 57 (85%) hatched. The other 10 failed to hatch for the following reasons:

Hummingbird, 4 (2 nests) destroyed by predation.

Kentucky warbler, 5; nest on low ground, flooded in heavy shower.

Hooded warbler, 1 sterile; other egg of clutch hatched.

Of 40 eggs laid in the control area, 30 (75%) hatched. The other 10 failed for the following reasons:

Wood thrush, 1 sterile; other eggs of clutch hatched.

Red-eyed vireo, 1 destroyed by predation (blue jay ?).

Red-eyed vireo, 1; water on egg—abandoned.

Red-eyed vireo, 1 sterile; other eggs of clutch hatched.

Parula warbler, 1 sterile; other egg of clutch hatched.

Kentucky warbler, 4 destroyed by predation.

Kentucky warbler, 1 sterile; others of clutch hatched.

Thus loss of eggs in both areas was comparable, and DDT had no noticeable effect on the eggs.

NESTLING MORTALITY

From 57 eggs hatched in the sprayed area, 35 young (61%) were fledged; the

TABLE 4.—RELATIVE NESTING SUCCESS IN AREAS OF BOTTOMLAND FOREST SPRAYED (1) AND UNSPRAYED (2) WITH DDT.

	Area	*Nests with eggs or young when sprayed*	*Nests which fledged young*	
Broad-winged hawk[a]	1	1	1	
	2	0	0	
Ruby-throated hummingbird	1	3	0	
	2	0	0	
Acadian flycatcher	1	6	1	
	2	1	0	
Tufted titmouse	1	1	1	
	2	0	0	
Wood thrush	1	2	1	
	2	3	3	
Red-eyed vireo	1	1	1	
	2	5	2	
Parula warbler	1	0	0	
	2	1	1	
Kentucky warbler	1	4	3	
	2	3	2	
Hooded warbler[a]	1	1	1	
	2	0	0	
Redstart	1	4	3	
	2	0	0	
Totals	1	23	12	(*52.2%*)
	2	13	8	(*61.5%*)

[a] In small areas of terrace forest (beech-white oak) within sprayed region; not in bottomland type.

others were accounted for as follows:

Acadian flycatcher, 15 nestlings destroyed by predation.
Wood thrush, 3 nestlings destroyed by predation.
Redstart, 4 nestlings dead in nest (see below).

Of the 35 young, 25 had already hatched at the time of spraying and would presumably be utilizing DDT-killed insects at the time of the heaviest insect kill. Of the 25, 21 were fledged, the other 4 being the redstarts.

From 30 eggs hatched in the control area, 24 young (80%) were fledged. The others were accounted for as follows:

Acadian flycatcher, 3 nestlings destroyed by predation.
Red-eyed vireo, 3 nestlings dead in nest (see below).

Of the 24 young, 12 had already hatched when Area No. 1 was sprayed; all of the 12 were fledged.

DISCUSSION

Thus, even disregarding the young redstarts possibly killed by DDT, normally operating factors caused higher mortality in the sprayed area than in the control area. The large loss of 15 Acadian flycatchers by predation accounts largely for the differences between the two areas in the summation of Column 2, Table 4; except for this loss, mortality rates seemed roughly comparable in the two areas.

Only in the case of one nest of juvenal redstarts is there any reason for considering DDT the cause of nestling mortality. Chemical analysis may show that these birds were killed by the DDT in their diet. However, in another nest, of red-eyed vireos being fed by their parents on June 8, the nestlings were dead on June 9, and the parents not in evidence. This nest was in the unsprayed area, a reminder that such fatalities can be expected normally.

CONCLUSIONS

The spraying of DDT at the rate of 2 pounds per acre on a tract of land within the well-drained bottomland forest at the Patuxent Research Refuge on June 5, 1945, had little or no effect on the bird population of the area, with the possible exception of the redstart (*Setophaga ruticilla*). Considerable evidence was accumulated showing that this species was probably somewhat reduced.

The effective dose for the treated area as a whole was decidedly less than 2 pounds of DDT per acre. Some spray was blown away to be deposited on nearby areas, and much of it was screened out by the dense forest canopy. The redstarts, being tree top feeders, were exposed to more DDT than most of the local birds.

EFFECT ON FOREST BIRDS OF DDT USED FOR GYPSY MOTH CONTROL IN PENNSYLVANIA[1]

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Between April 18 and June 28, 1945, the birds populations on three tracts near Scranton, Lackawanna County, Pennsylvania were determined by repeated, systematic census trips.

One tract ("Mile Square") comprised about 40 acres adjacent to a ¾-mile trail in Spring Brook Valley, 6 miles south of Scranton. The trail extends from one edge to beyond the center of a forested area of about 600 acres that in late May and early June was sprayed by airplane with 5 pounds of DDT per acre for experimental control of gypsy moth larvae and to determine the effect of DDT upon other insects. This dosage is several times that needed for control of the gypsy moth and is the maximum considered necessary by entomologists for any forest insect pest.

The second tract ("Maple Lake"), 6 miles southeast of Scranton and one mile west of Maple Lake, comprised 40 acres in an area of about 350 acres of rolling land mostly forested. The area was sprayed by airplane on June 9 with 1 pound of DDT per acre for experimental control of gypsy moth larvae and to determine the effect of this concentration on other insects.

The third tract ("Check"), 6 miles southeast of Scranton and a mile northwest of Maple Lake, was a 40-acre portion of an extensive untreated forest area.

Birds were censused in the Mile Square tract because its insect population was being studied carefully by the Bureau of Entomology and Plant Quarantine and because it later received a heavier application of DDT than the Maple Lake tract. More detailed work was done on the Maple Lake and Check tracts because preliminary examination indicated that they had more birds per acre and so might show changes in population more clearly.

Methods

Before May 1, the boundaries of the Maple Lake and Check tracts were surveyed by combined use of airplane photographs (Agricultural Adjustment Administration), the maps and survey lines made by the Wilkes-Barre gypsy moth office, and by pocket compass and pacing. North-south lines were surveyed at 100-foot intervals and marked by

[1] This investigation was made with cooperation of three divisions of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine: Gypsy Moth and Brown-Tail Moth Control; Forest Insect Investigations; and Insect Identification. J. M. Corliss of the Wilkes-Barre office of the Bureau provided several assistants on short notice and furnished a truck and other equipment. Each division had men in the field constantly, who obtained information on changes in insect populations and much on environmental conditions, and were otherwise helpful.

paint blazes. Maps (1 inch: 200 feet) were prepared from these data and from further use of compass and pacing to locate fences, streams, crests of steep slopes, and boundaries of plant communities. Descriptions of the plant communities are based on observations continued through the entire period.

The trail in the Mile Square tract was surveyed and mapped by the Bureau of Entomology and Plant Quarantine.

Between May 1 and June 27, bird populations were determined in the three tracts by repeated census trips, mostly during the early morning song period of 2 to 5 hours. All birds seen or heard on a trip were plotted on a map; later from a series of these maps the territories of each species were mapped for each tract. Territories were plotted mostly from the location of singing birds, some undoubtedly being unmated males. Each tract was treated similarly, hence the resulting population figures in pairs of breeding birds are believed comparable.

The Mile Square tract was censused from or close to the trail, along which 43 insect trays had been placed at 75-foot intervals from the highway to the top of the ridge. Distances were not marked from there to the end of the trail. Censuses were made from May 11 to 25 (7 trips) and from June 1 to 26 (8 trips). Birds were recorded on both going and return trips. Spraying of the 600 acres with DDT in oil at 5 pounds per acre extended from May 24 to June 1, due to bad weather. Special trips were made to portions of the trail and adjoining forest on May 27 and 31. Most of the observations were made by Pough.

In the Maple Lake and Check tracts, the north-south lines were followed on census trips. Several times after the middle of the season alternating lines were followed instead of every 100-foot line; and several times the route was reversed so that any part of a tract might be covered at different hours in the morning. The two observers also frequently changed places in covering the same area. The Maple Lake tract was censused 13 times between May 1 and 29, and seven times from June 6 to 27. The 350-acre area enclosing that tract was sprayed on June 9 with DDT in oil at 1 pound per acre. Special trips were made to the tract on June 9 and 10. The Check tract was censused on nine days from May 2 to 31, and on June 7, 13, and 21.

ENVIRONMENTS

Mile Square Tract. The trail extends southwestward from State Highway 502, near the bottom of Spring Brook Valley, to the crest of a broad ridge. It ascends about 500 feet in two-thirds of a mile, then follows the ridge into a saddle. A small brook, dry in summer, parallels the lower trail a few rods to the southeast. The forest is of dense second-growth hardwoods, mostly under 12 inches in diameter and less than 40 feet in height. For more than half of the way up the slope white oak is dominant, then is replaced by chestnut oak. Pure scrub oak covers the higher part of the ridge. The saddle has considerable pitch pine mixed with hardwoods. An undergrowth of heath shrubs occurs along most of the trail.

Maple Lake Tract. This tract is roughly oblong, 1,000 by 2,000 feet, lengthwise of which flows a small permanent brook that traverses a

10-acre swamp in the western half of the tract. North of the swamp and brook, about 20 acres of hardwood forest slopes gently up to the north. South of the swamp there are 5 acres of flat to undulating wet woods, and to the east 3 acres of recent clear cutting; on the west are 2 acres of knolls with scattered trees.

The swamp is dominated by red maple, scattered in the western half and dense in a narrow marginal fringe elsewhere. With the maple are some yellow birch and hemlock, the latter abundant in the understory of the marginal fringe. Westward under the scattered red maples there is dense shrubbery, with alder and rhododendron dominant; eastward the swamp is open grass marsh.

The upland hardwood forest is dominated by red maple, while sugar maple, beech, and several other species are intermixed in most places. Much of this forest has a broken canopy and almost no woody undergrowth. Northeastward are a dozen irregular clearings having a total area of 3 acres. Mountain-laurel is abundant in two partly open localities, and hayscented fern is a dominant ground cover save in the denser woods.

The wet woods are principally red maple, yellow birch, and gray birch, with an abundant undergrowth of mountain-laurel, highbush blueberry, and meadowsweet. Hardhack and hayscented fern are conspicuous among the red maple and gray birch scattered over the knolls.

Three-fourths of the tract was being pastured by cattle—all except the west end of the swamp, the upland woods north of it, and the densely wooded margin of the swamp. Long-time pasturing following logging apparently was responsible for the lack of woody undergrowth in much of the upland forest.

Check Tract. This is an oblong area, 1,000 by 2,000 feet, cut obliquely at the north end. A permanent brook flows across the area, mostly through an open-wooded swamp of about 10 acres. Northwest and southeast of the swamp the land rises rather steeply to the limits of the tract, possibly to 100 feet or more. To the northwest, approximately 13 acres of upland is covered with hardwood forest and 3 acres with scattered gray birch and quaking aspen. Southeast the forest comprises 6 acres of steep slopes with dense hemlock understory, 6 acres of more gently sloping mature forest without a dense understory, and 2 acres of open woods.

Red maple, hemlock, and yellow birch are dominant in the swamp, and alder and rhododendron and many herbs are abundant. In the northwestern upland forest red maple, beech, sugar maple, and black cherry, are dominant, with an abundant ground cover of hayscented fern and clubmosses. Among the scattered gray birch and quaking aspen are many herbs.

Southeast of the swamp the forest on the steep slopes is dominated by red maple and beech, with dense hemlock beneath; in the open woods red maple is dominant, with ferns and clubmosses abundant as ground cover. On the gently sloping upland sugar maple, beech, and yellow birch are abundant, with ferns, clubmosses, and other herbs covering the ground. None of the tract appears to have been pastured in recent years.

BIRDS

The main migration was just beginning on May 1, therefore the early censuses were not used in plotting the territories of most species. At the time DDT was applied to the Mile Square tract (May 24 to June 1) most of the birds were beginning to nest, but there were still a few present that presumably migrated. Scarcely any of the birds were believed to have left the Maple Lake and Check tracts after spraying of the former on June 9.

Four nests were found in the Mile Square tract, 16 in the Maple Lake tract, and 3 in the Check tract. There was considerable abandonment and nestling mortality, but except for 2 nests in the Mile Square none was attributed to DDT.

Mile Square Tract. Prior to the spraying, the pairs of birds were estimated as follows (largely on the basis of singing males, the numbers indicating possible pairs):

Sharp-shinned hawk	1
Hairy woodpecker	1
Crested flycatcher	2
Black-capped chickadee	1
Hermit thrush	Several in distance
Red-eyed vireo	14
Black-and-white warbler	4
Worm-eating warbler	1
Golden-winged warbler	1
Nashville warbler	1
Black-throated blue warbler	2
Chestnut-sided warbler	1
Ovenbird	21
Yellowthroat	1
Redstart	4
Scarlet tanager	2
Indigo bunting	2
Towhee	4
Field sparrow	1
Total	64 (1.6 pairs—3.2 birds per acre)

On the morning of May 26, about 48 hours after application of DDT, two red-eyed vireos and one redstart were found on the ground twitching violently; each died soon after. One other vireo seemed to be affected but was not caught.

On June 2 a red-eyed vireo was found with symptoms of DDT poisoning about 24 hours after application of DDT to the upper trail; it died within a few hours. On June 3 a dying ovenbird was found on its back below an empty nest (bird sitting on June 2) and one nest of black-throated blue warbler discovered on June 2 apparently was abandoned. Only a few living birds remained on the tract. On June 4 one dead scarlet tanager and one dead black-and-white warbler were found; the only living birds located were one each of towhee and yellowthroat.

All gypsy moth larvae apparently were exterminated. Many other insects were killed by the spray, and insects still were scarce at the end of June.

Census of the area on June 7 showed considerable increase in the bird population from the low point of June 4 and this increase continued. On June 13 the following singing males were located:

Crested flycatcher	1
Brown thrasher	1
Hermit thrush	Several in distance
Red-eyed vireo	6
Black-and-white warbler	2
Black-throated green warbler	1
Ovenbird	4
Scarlet tanager	2
Towhee	4
Total	21 (0.5 bird per acre)

No appreciable increase in numbers or changes in species took place during the remainder of the period.

Maple Lake Tract. The estimated

number of pairs (largely on basis of singing males) before spraying was:

Red shouldered hawk	1
Ruffed grouse	5
Flicker	1
Hairy woodpecker	1
Downy woodpecker	2
Crested flycatcher	1
Blue jay	1
Black-capped chickadee	4
Catbird	4
Hermit thrush	5
Red-eyed vireo	12 or 13
Black-and-white warbler	5
Nashville warbler	2
Magnolia warbler	9
Black-throated green warbler	3–5
Chestnut-sided warbler	1
Ovenbird	14
Northern water-thrush	7
Yellowthroat	4
Canada warbler	10
Redstart	5 or 6
Baltimore oriole	1
Scarlet tanager	3
Rose-breasted grosbeak	1
Towhee	5 or 6
Song sparrow	2 or 3
Total	109–115 (2.7 pairs per acre)

Most of the gypsy moth larvae were killed. Other insects were conspicuously reduced immediately after the spraying, but never became as scarce as in the Mile Square tract. By the end of the period they were fairly common.

The bird population remained nearly unchanged during nearly three weeks following the application of DDT. The only changes were the apparent disappearance of three pairs of red-eyed vireos, one pair of black-and-white warblers, one pair of magnolia warblers, and one or two pairs of black-throated green warblers. A pair or two of song sparrows appeared after the spraying. This reduced the population a maximum of six pairs to a total of 103–109 (2.6 pairs per acre).

Check Tract. Before the date of spraying of the Maple Lake tract, the estimated pairs in the Check tract were:

Broad-winged hawk	1
Ruffed grouse	3
Blue jay	1
Black-capped chickadee	3
White-breasted nuthatch	1
Hermit thrush	1
Veery	20
Red-eyed vireo	17
Black-and-white warbler	3
Magnolia warbler	9
Black-throated green warbler	5
Blackburnian warbler	1
Ovenbird	17
Northern water-thrush	5
Yellowthroat	2
Canada warbler	9
Redstart	6
Scarlet tanager	4
Total	108 (2.7 pairs per acre)

The insect population remained large throughout the period of observation.

Changes in the bird population of the Check tract were comparable to those of the Maple Lake tract. Those noted were the apparent disappearance of one pair of ruffed grouse, one pair of chickadees, three of veerys, one of red-eyed vireos, one of black-and-white warblers, one of ovenbirds (one other pair appeared after June 9, the date on which the Maple Lake tract was sprayed), and four of redstarts. This reduced the population by 11 pairs to a total of 97 (2.4 pairs per acre).

CONCLUSIONS

1. A single airplane application of DDT in oil at 5 pounds per acre to a forest in northeastern Pennsylvania at a time of great activity among plants, insects, and birds resulted in the death of birds and a conspicuous reduction in the breeding population. From the finding of several affected birds in a small portion it was concluded that the initial kill was high. The continued reduction in population may have been

due to initial kill or to the exclusion of birds through a reduced food supply.

2. A single application at 1 pound per acre under similar conditions had no measurable effect on the breeding birds.

3. Reduced insect populations resulted from both concentrations of DDT and this reduction may affect insect populations of the following year, hence the ultimate effects can be determined only by study of each of these areas during June 1946.

SUMMARY

1. Systematic censuses of the birds on three 40-acre tracts of forest near Scranton, Lackawanna County, Pennsylvania, were made between May 1 and June 27, 1945, to determine the breeding populations.

2. Between May 24 and June 1 a 600-acre area enclosing the first (Mile Square) was sprayed by airplane with DDT in oil solution at 5 pounds per acre. On June 9 a 350-acre area enclosing the second tract (Maple Lake) was sprayed with 1 pound of DDT per acre. The third tract (Check) was not treated.

3. Within 48 hours after treatment of the Mile Square tract, five sick birds were found with symptoms of DDT poisoning, and all died. Two other dead birds were found, and two nests apparently were abandoned. Species involved were red-eyed vireo (3), black-and-white warbler, black-throated blue warbler (nest abandoned), ovenbird (bird died, nest abandoned), redstart, and scarlet tanager.

Within 48 hours after application of DDT to the final portion of the tract (on June 1) the population of living birds appeared to have been much reduced, and this condition continued. Before spraying the population total for all species was 1.6 pairs (3.2 birds) per acre. Three days after spraying had been completed there were only two singing males in the entire area; but on June 13 the estimated population was 0.5 bird per acre.

4. After DDT was applied to the Maple Lake tract, careful watch was kept for changes in the bird population and as to nest conditions there and on the Check tract. The apparent total reduction for all species in the Maple Lake tract was from 2.7 pairs to 2.6 pairs per acre; and in the Check tract from 2.7 pairs to 2.4 pairs per acre. Neither these changes nor the observed abandonment of nests and nestling mortality could be attributed to use of DDT.

EXPERIMENTS ON TOXICITY OF DDT TO WILDLIFE[1]

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There has been much basic experimental work toward determining the possible hazards of DDT to man and the domestic animals. The resulting data indicate a varied toxicity depending upon the degree of absorption in the intestinal tract (1, 2, 3, 4, 5, 6).

To obtain exact information on the acute and chronic toxicity of DDT for representative wild mammals and birds, experiments were made at the Patuxent Refuge with the bobwhite quail (*Colinus virginianus*), mallard (*Anas platyrhynchos*), American pintail (*Dafila acuta*), starling (*Sturnus vulgaris*), cottontail rabbit (*Sylvilagus floridanus*), meadow mouse (*Microtus pennsylvanicus*), and white-footed or deer mouse (*Peromyscus leucopus*). DDT was administered orally either in single (acute) or repeated (chronic) doses, and the animals were observed for varying lengths of time as to symptoms and lethal action.

Acute oral toxicity was studied by administering a single dose of DDT, either in crystalline form or in vegetable oil solution. Most of the tests were run with crystalline DDT because it is in this form, with existing formulae, that terrestrial species would come in contact with the chemical in their natural habitats. The compound was administered orally, using a syringe and soft rubber catheter. For mice a blunt No. 18 hypodermic needle was used, and for quail the DDT was measured into a gelatin capsule which then was inserted into the crop. All birds and animals were maintained for several weeks prior to the dosing on an adequate diet with food and water offered ad libitum; they were fasted for 24 hours prior to weighing and dosing. The dosages administered were calculated on the fasted weight. Following administration of DDT the various species were placed on their regular diets and observed periodically for symptoms.

[1] Dr. C. A. Hoffman, Bureau of Entomology and Plant Quarantine, and Clyde Vance, U. S. Fish and Wildlife Service, gave technical assistance in these studies.

Bobwhite Quail

Bobwhites of both sexes, and weighing 122 to 180 grams were used. No difference in reaction of males and females was evident. The acute toxicity of DDT for this species when administered orally, is 60 to 85 milligrams per kilogram in oil solution and about 300 mg./kg. in the crystalline form (Table 1). Tremors, when present, usually developed on the second day.

Using 5-week-old quail, groups of 10 birds each were placed on a diet containing the following percentages of DDT: 0.4; 0.2; 0.1; 0.05; 0.025; 0.010; 0.005; and none (Table 2). At 0.40 to 0.05 per cent all of the birds died. There was about 50 per cent mortality at 0.025 per cent of the diet. Some losses, possibly related to DDT poisoning, resulted when amounts as low as 0.005 per cent were fed over a period of 63

days. Slight tremors in some birds in this group were the only observed symptoms of DDT poisoning, and post-mortem examination showed evidence of cannibalism only. The daily food consumption for 5- to 6-week old birds has been found to be about 5 to 11 grams per bird. An average of 12 grams

TABLE 1.—BOBWHITE QUAIL. ACUTE TOXICITY OF CRYSTALLINE DDT.

DDT mg./kg.	Days on experiment	Birds used	Reactions			
			Normal	Tremors		Dead of DDT intoxication
				Slight	Severe	
CRYSTALLINE						
50	22	2	2	—	—	—
100	22	7	7	—	—	—
200	22	5	5	—	—	—
300	1–28	6	2	—	1	3 (1 or 2 days)
400	1–31	6	—	4	1	1 (2 days)
500	1–21	6	1	1	—	4 (1 or 2 days)
600	1–21	6	2	1	—	3 (1 or 2 days)
700	1	2	—	—	—	2 (1 day)
800	1–3	2	—	1	—	1 (1 day)
850	1–2	2	—	1	—	1 (1 day)
900	1–31	2	1	—	—	1 (1 day)
1,000	1–21	6	1	3	2	—
IN SOYBEAN OIL SOLUTION						
40	30	4	4	—	—	—
50	1–24	6	4	—	1	1 (1 day)
60	1–24	6	2	—	—	4 (1 day)
75	1–30	6	1	—	—	5 (1 to 9 days)
85	1	2	—	—	—	2 (1 day)
100	1	2	—	—	—	2 (1 day)
200	2–21	2	—	1	—	1 (2 days)
500	1–2	2	—	—	—	2 (1 or 2 days)
1,000	1	2	—	—	—	2 (1 day)

TABLE 2.—BOBWHITE QUAIL. CHRONIC TOXICITY OF DDT IN MASH.
(10 birds in each group)

DDT percentage in diet	Average weight at start, grams	Average daily consumption			Birds alive at end of day							
		Food (grams)		DDT (mg.)								
		1st 7 days	63-day period		1	2	7	14	21	28	35	63
Control	60	6.5	11.7[c]	—	10	10	9	9	9	9	9	9
0.005	57	8.6	12.5	0.62	10	10	10	10	10	10	10	7
0.01	72[a]	10.3	12.7	1.23	10	10	10	9[b]	9	9	9	7
0.025	66[a]	11.2	12.3	3.07	10	10	9[b]	8[b]	7	7	6	3
0.05	61	5.3	7.9	3.95	10	10	8	2	2	0	0	0
0.10	54	4.8	—	4.8	10	10	0	0	0	0	0	0
0.20	47	2.3	—	4.6	8	2	0	0	0	0	0	0
0.40	55	2.3	—	9.2	0	0	0	0	0	0	0	0

[a] 6 weeks old at start; all others 5 weeks old.
[b] One died of causes other than DDT poisoning.
[c] 21 days.

per bird per day was consumed during the entire 63-day feeding period.

MALLARD AND PINTAIL

Chronic toxicity tests of DDT in wild-trapped birds, mallard and pintail, were complicated by the nature of these birds; their reaction to restraint in cages resulted in many injuries and irregular feeding. In consequence, loss in weight and death often was the result of this situation rather than DDT toxicity. Lttle trouble was experienced with ducks held in a large community pen for the acute toxicity tests.

Adult wild mallard and pintail ducks were fed diets containing DDT at percentages of 0.4; 0.2; 0.1; 0.05; 0.025; and zero. They evidenced toxicity due to DDT in all levels above 0.025 per cent (Table 3). There was consistent regularity in the appearance of symptoms and mortality in the higher percentage groups. No toxic effects were noted in the birds at the 0.025 per cent level, and a gain in weight was recorded for one bird of this group.

TABLE 3.—MALLARD AND PINTAIL. CHRONIC ORAL TOXICITY OF CRYSTALLINE DDT.

DDT percentage in diet	Weight at start, grams	Loss in weight, grams	Results
Control	725	127	43d day, released.
	1,065	449	10th day, failed to eat.
	912	28 gain	30th day, released; no DDT symptoms.
0.025	1,173	101	30th day, released; no DDT symptoms.
	887	236	17th day, dead; no DDT symptoms.
	1,082	92	30th day, released; no DDT symptoms.
	1,071	57 gain	30th day, released; no DDT symptoms.
0.050	954	79	16th day, dead; no DDT symptoms.
	857	109	16th day, tremors; 19th day, dead.
	1,055	284	17th day, tremors; 19th day, dead.
	956	170	23d day, tremors; 32nd day, dead.
0.100	831	187	11th day, dead of cage injury.
	823	245	Loss of appetite and weight; 21st day, dead.
	872	166	Loss of appetite; cage injury; 11th day, dead.
	1,456	605	Loss of weight; 29th day, died; no DDT symptoms.
0.200	901	—	14th day, tremors; 30th day, released.
	909	301	14th day, partial paralysis; 20th day tremors; 22d day, dead.
	940	104	Refused food; 5th day, dead of cage injury.
	1,273	347	11th day, tremors; 14th day, paralysis; 19th day, dead.
0.400	847	239	8th day, loss of appetite; 9th day, tremors; 12th day, dead.
	999	216	8th day, loss of appetite; 9th day, tremors; 14th day, dead.
	1,000	328	8th day, loss of appetite; 9th day, tremors; 16th day, dead.
	1,160	288	8th day, loss of appetite; 9th day, tremors; 14th day, dead.

Acute toxicity tests were made by feeding crystalline DDT in capsules at 500, 1,000, and 2,000 mg./kg., respectively, of body weight (Table 4). Toxic reaction shown by tremors was observed in birds receiving the 2,000 mg./kg. dose, although no fatalities

occurred in any of the birds tested. All were held for observation for 30 days, then released as normal.

TABLE 4.—MALLARD AND PINTAIL. ACUTE TOXICITY OF CRYSTALLINE DDT.

Dosage, (mg./kg.)	*Weight, grams*	*Dose, mg.*
500	1,062	531
500	904	452
1,000	1,030	1,030
1,000	856	856
2,000	753	1,506[a]
2,000	736	1,472
2,000	881	1,762

[a] Tremors on 2d day; all others normal at end of 30 days.

STARLING

Acute oral toxicity tests were handicapped by many cage injuries and the refusal of some birds to eat in captivity. The starlings were confined in wire cages (6×6×8 feet), which permitted flight. Shelter with wind protection and pine branches for roosting were provided. The cages was in a field protected by a guard fence where the only disturbances were activities of the attendant in feeding, introduction of new birds, and removal of dead specimens. The food consisted of cracked grain at all times and daily feedings of ground horse meat. Wild-caught birds were used, on which age determinations could not be made.

Dosings were made of finely divided crystalline DDT in aqueous suspension (1% gum acacia). Doses at 100, 300, 400, 500, and 600 mg./kg., respectively, were administered by stomach tube to 32 birds; eight undosed birds were caged with the test starlings as controls (Table 5).

The only clinical evidence which might be interpreted as a toxic reaction consisted of what is best described as a lethargic condition. Three birds showed this reaction on the 25th, 32nd, and 39th days, respectively. One was in the 300 mg./kg. group and two in the 500 mg./kg. group, but there was none at the 600 mg./kg. level; it is doubtful, therefore, that this reaction should be attributed to DDT poisoning. Tremors were not observed at any time. Postmortem examination of birds which died during the test usually revealed ample other causes for death, but no evidence of DDT intoxication. Save

TABLE 5.—STARLING. ACUTE TOXICITY OF CRYSTALLINE DDT.

DDT mg./kg.	Days on experiment	Birds used	Reaction			
			Normal	Tremors		Dead of DDT intoxication
				Slight	Severe	
Control	30	4	4	—	—	—
100	30	2	2	—	—	—
300	30–40	5	1	—	—	[a]
400	24–30	5	4	—	—	1[b]
500	29–59	4	1	—	—	[c]
600	2–27	7	2	—	—	[d]

[a] One sacrificed, showed liver damage; 1 dead of inanition; 2 dead, cause unknown.
[b] Sacrificed, minor DDT injury to liver.
[c] Two dead of inanition; 1 dead, cause unknown.
[d] Two dead of inanition; 3 sacrificed, DDT liver injury.

for the 400 mg./kg. group, in which only one bird died, the highest rate of survival occurred in the group receiving the heaviest dosage. Five of the nine dosed at 600 mg./kg. were released on the 20th day as normal. Histological examination showed damage to the liver and kidneys from dosings at 600 mg./kg.

COTTONTAIL RABBIT

Finely ground DDT was mixed intimately with the diet and fed to two groups of five and four rabbits at 0.2 and 0.4 per cent levels, respectively (Table 6). In the group on 0.2 per cent, three survived but all four animals showed slight tremors between the 19th and 32nd day. One died on the third day from other causes, having consumed no feed. Postmortem findings in rabbit No. 5 (died on 34th day) indicated chronic DDT poisoning. This animal showed a gain in weight for the 34-day period of 84 grams and a daily food consumption of 69 grams. The average daily food consumption for the group was 64 grams.

TABLE 6.—COTTONTAIL RABBIT. CHRONIC TOXICITY OF CRYSTALLINE DDT.

DDT percentage in diet	Initial body weight, grams	Change in weight, grams	Average daily food eaten, grams	Days survived
0.2	1,225	+129	73.3	35*
0.2	1,116	−286	62.5	39*
0.2	962	+ 84	60.1	34
0.2	1,101	− 63	60.0	39*
0.4	1,031	− 14	57.0	15
0.4	1,076	−298	52.6	19
0.4	1,060	−117	68.0	42*
0.4	1,114	− 97	47.0	21

* Released.

Three of four cottontails fed at the 0.4 per cent level died by the 21st day. All rabbits showed slight to severe tremors, some of several days duration, during the test. Death of rabbit No. 21, as shown by postmortem examination, was directly due to an acute pneumonia, possibly related to DDT toxicity. This group experienced an average loss in weight of 134 grams and an average daily food intake of 54 grams.

For the tests of acute oral toxicity, single doses of crystalline DDT (aqueous suspension in 1% gum acacia) were administered by stomach tube at levels of 500, 1,000, 1,500, 2,000, and 2,500 mg./kg. (Table 7). Evidence of toxicity by production of severe tremors was shown in only one of three dosed at the 1,500 mg./kg. level, in two of four at 2,000 mg./kg., and in two of three at the 2,500 mg./kg. level. Three of these five, including one from each group, showed subsequent return to normal and survived the tests. The birth of young by two animals was considered unrelated to the toxicity tests.

Postmortem findings in rabbit No. 16 indicated that it died of DDT poisoning although no clinical evidence of intoxication was observed. No. 15 died of coccidiosis 11 days after apparent recovery from the toxic effect of DDT dosing. Nos. 19 and 20 both showed pleurisy and pulmonary edema as the cause of death seven and 12 days, respectively, following dosing. The possibility that the latter condition resulted from inhaling some foreign material at time of dosing could not be eliminated. The recovery of the third animal in this group, following marked clinical symptoms, indicates that the minimal lethal dose for the cottontail is greater than 2,500 mg./kg.

TABLE 7.—COTTONTAIL RABBIT. ACUTE TOXICITY OF CRYSTALLINE DDT.

DDT dose, (mg./kg.)	Weight, grams	Dose administered, grams	Days on experiment	Remarks
500	1,079	0.540	26	Normal; released
500	1,176	0.588	31	Normal; liver and kidney injury
750	1,069	0.802	25	Normal; released
750	994	0.746	31	Normal
1,000	954	0.954	31	Normal; liver and kidney injury
1,000	1,329	1.329	24	Normal; released
1,000	1,277	1.277	24	Normal; released
1,500	1,069	1.604	24	Normal; released
1,500	1,114	1.671	24	Severe tremors, 2d day, decreasing to slight; normal on 3d day
1,500	949	1.424	24	Normal; released
2,000	985	1.970	3	DDT intoxication
2,000	1,349	2.698	34	Normal; 5 young born alive 3d day
2,000	1,144	2.288	10	Slight tremors 2d day; normal 3d day; liver and kidney injury
2,000	1,158	2.316	10	Extreme tremors 2d day; aborted 3 young; normal; released
2,500	1,087	2.718	4	DDT intoxication; three young born 2d day
2,500	1,118	2.795	12	Slight tremors 2d day; normal 4th day; DDT intoxication
2,500	1,016	2.540	30	Severe tremors 2d day; normal 4th day; released

MEADOW MOUSE

In the conduct of chronic toxicity tests with the meadow mouse and white-footed mouse, a diet of 40 per cent corn, 40 per cent wheat, and 20 per cent ground oatmeal was used. Finely ground DDT was mixed intimately with the diet. Chronic DDT toxicity occurred in meadow mice at the 0.2 per cent level, as clearly demonstrated by marked tremors in three of five and the death of two within a period of 28 days. All of the five fed DDT at the 0.4 per cent level died by the 21st day, whereas, all fed at lower levels survived the 31-day test period. Slight gains in average weights were recorded for animals in most groups, including those on toxic levels. Data are presented in Table 8.

WHITE-FOOTED MOUSE

The acute oral toxicity of crystalline DDT for the white-footed mouse is close to 1,500 mg./kg. (Table 9). Three at this level died within 24 hours, but the other three survived and appeared normal during a 9-day observation period. Moderate to severe tremors were shown by all members of this group and histologic study of tissues from the survivors revealed damage to the liver and kidneys. Clinical evidence of toxicity was not shown by animals dosed at 1,000 mg./kg. and all survived. Five of six dosed at 2,000 mg./kg. died within 3 to 49 hours; the other survived following severe tremors.

Feeding of DDT in the diet at levels of 0.01, 0.02, 0.04, and 0.10 per cent,

TABLE 8.—MEADOW MOUSE. CHRONIC TOXICITY OF CRYSTALLINE DDT. (5 animals in each group; test period 31 days)

DDT percentage in diet	Average weight		Average daily food eaten, grams	Number surviving
	At start, grams	At end, grams		
Control	30.0	35.75	5.1	4
0.01	36.2	30.0	4.8	5
0.02	33.0	38.0	5.9	4; one escaped 27th day
0.04	35.4	39.2	5.2	5
0.10	31.4	31.8	4.5	5
0.20	37.2	38.5[a]	5.2	3
0.40	34.8	—	4.6	0; two dead on 4th day; 2 more by 8th day; last died on 21st day

[a] Average of 3, 16th day; terminal weight not taken.

respectively, did not produce clinical evidence of toxicity in any instance during a 30-day trial. Slight tremors developed by the third day in all animals fed at 0.2 and 0.4 per cent. Tremors disappeared on the fifth day and did not reappear during the remainder of the experiment. Average daily food consumption was slightly less in the two highest feeding levels, although no mortality could be ascribed to the action of the drug (Table 10).

SUMMARY AND CONCLUSIONS

Toxicity tests of DDT for four species of birds and three of mammals were made in cages at the Patuxent Research Refuge and the levels of acute and chronic poisoning were determined for most of them. Results of these ex-

TABLE 9.—WHITE-FOOTED MOUSE. ACUTE TOXICITY OF CRYSTALLINE DDT.

DDT dose, (mg./kg.)	Weight, grams	Survival time	Remarks
1,000	19	Held 9 days	Survived
	23	Held 9 days	Survived
	14	Held 9 days	Survived
	18	Held 9 days	Survived
1,500	20	24 hours	Severe tremors 2d day
	18	Held 9 days	Slight tremors 4th day; survived
	19	Held 9 days	Slight tremors 4th day; survived
	19	Held 9 days	Slight tremors 4th day; survived
	14	19 hours	Moderate tremors 1st day
	15	6 hours	Moderate tremors 1st day
2,000	17	20 hours	—
	17	35 hours	Severe tremors 2d day
	16	20 hours	—
	19	49 hours	Slight tremors 2d day
	17	3 hours	—
	19	Held 3 days	Survived

periments indicate a considerable variation in the toxic action of DDT due to variations in rate of absorption, elimination and/or differences in physiological reaction in the animals studied.

The data for bobwhite quail indicate that the toxic action of crystalline DDT

TABLE 10.—WHITE-FOOTED MOUSE. CHRONIC TOXICITY OF CRYSTALLINE DDT.

DDT percentage in diet	Average weight		Average daily food eaten, grams	Number surviving
	At start, grams	At end, grams		
control	25.2	23.7	3.54	4
0.01	24.2	23.7	3.50	4
0.02	22.6	22.0	3.25	4
0.04	23.8	23.5	3.18	4
0.10	23.0	22.2	4.15	4
0.20	17.0	16.4	2.57	5
0.40	23.2	18.0	2.40	4

is very irregular because of low and variable absorption. Lethal activity of crystalline DDT is correspondingly irregular; dosages up to 200 mg./kg. are required for a significant percentage of deaths. Groups fed increasingly large doses showed high mortality rate, but survivals occurred in nearly all even at 1,000 mg./kg.

The acute toxicity of DDT for bobwhite quail is 60 to 85 mg./kg. when orally administered in oil solution, and about 300 mg./kg. when administered orally in crystalline form. The greater toxicity in vegetable oil solution undoubtedly is due to the higher rate of absorption. Five-week old quail, fed at levels of 0.05 to 0.4 per cent DDT in the diet died, and there was 50 per cent mortality at 0.025 per cent. Some losses resulted with as little as 0.005 per cent. There were typical symptoms of DDT poisoning, many of the birds showing excessive nervousness, anorexia, and tremors prior to death.

Adult wild mallard and pintail ducks evidenced toxicity to DDT for all levels above 0.025 per cent in the diet. Toxic reactions were observed in birds receiving 1,000 mg/kg., but no fatalities occurred in any dosed at this level.

Evidence of acute toxicity in the starling by oral dosing was found only by histological study of the liver and kidneys. Lesions were observed only in birds dosed at 600 mg./kg. Five of nine birds dosed at this level were released on the 28th day as normal.

Resistance to restraint of wild ducks and starlings precluded exact determinations of toxicity in these species. Sufficient evidence was obtained in both cases, however, by symptoms or by histological study, to determine the levels of both chronic and acute poisoning in the ducks and of acute poisoning in the starlings.

In the cottontail rabbit, evidence of toxicity was seen in only one of five at 0.2 per cent DDT in the diet for a period of more than three days. Three of four rabbits at the 0.4 per cent level died by the 21st day, after showing severe tremors. Multiple areas of focal necrosis in the livers and kidneys of these animals were seen in tissue preparations. Individual variation in resistance to single doses was evident in the cottontail. No evidence of acute intoxication was shown by any below the 1,500 mg./kg. level. Two of four at 2,000 mg./kg. and two of three at 2,500 mg./kg. showed clinical evidence of intoxication, although animals from both groups returned to normal and survived the test. This indicates that

the minimal lethal dose for this species is near the 2,500 mg./kg. level.

Chronic toxicity occurred in meadow mice at 0.2 per cent DDT in the diet, as shown by the development of marked tremors and the death of two among five animals within the period of 28 days. The five fed at the 0.4 per cent level died by the 21st day of the feeding period. All animals fed at levels lower than 0.2 per cent of the diet survived the 31-day test period.

Three of six white-footed mice dosed at 1,500 mg./kg. died of DDT intoxication within 24 hours, but the other three survived. Moderate to severe tremors were shown by all members of this group and characteristic lesions of DDT injury were observed in tissues of the animals which survived. Five of six dosed at 2,000 mg./kg. died within 3 to 49 hours. Chronic toxicity tests resulted in the production of clinical symptoms only in those fed diets containing DDT in excess of 0.1 per cent.

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FIELD STUDIES OF A PEROMYSCUS POPULATION IN AN AREA TREATED WITH DDT

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A cooperative experiment to evaluate the effects on the vertebrate animals of application of DDT to a forested area was conducted on the Patuxent Research Refuge in the spring and summer of 1945. Population studies of the deer mouse (*Peromyscus leucopus*) on the experimental area were a part of this program.

METHODS

The area selected for treatment was a 117-acre tract of bottomland forest; another area of similar type 1½ miles distant but not sprayed was studied as a control. Aerial application of DDT in oil at 2 pounds per acre was made June 5, 1945.

Spectrophotometric analysis of DDT

deposited on Petri dishes at ground level showed that much of the spray was screened out by the heavy forest canopy. An average of 0.05 pound per acre was recorded for the open forest floor, and 0.008 pound per acre for areas protected by the canopy and some form of ground vegetation. Observation showed that a considerable amount of DDT drifted away, some being deposited on nearby areas. The studies on DDT deposits showed that the deer mice were not likely to obtain lethal concentrations of DDT on their plant food, but might suffer from eating poisoned insects that fell from the trees.

The habitat sprayed and other pertinent information on the DDT application are described by R. E. Stewart *et al.*, "Effects of DDT on birds at the Patuxent Research Refuge" (Journ. Wildl. Mgt., 10: 195, 1946).

The general plan for testing the effects of DDT on the deer mouse population was to live-trap, mark and release these animals according to a standardized plan in both the treated and check areas. Two periods of sampling by trapping were carried on in each area, one before and one after the treatment. Trapping was conducted simultaneously in the two areas and by the same methods. Comparison of the data so obtained should demonstrate any possible effect of the DDT treatment.

The sampling method was a modification of that used by workers in the Bureau of Animal Population at Oxford, England, for measuring population fluctuations.[1] Conclusions were based on the results of 500 trap nights in the two areas studied. Five rows of five traps each, with traps 165 feet apart in the row and rows 165 feet distant from each other, were set up in the experimental area, and an identical trapping unit in the check area. The Sherman-type metal box-traps were used, baited with rolled oats and peanut butter and supplied with cotton for nesting material. Animals trapped were marked in the field using an ear-punch, toe-clip system, and then released at the point of capture.

The first trapping was conducted May 2 to May 7. DDT was applied June 5, and the second trapping was done June 14 to June 19. The exact trap locations for the first trapping were marked and the traps placed in these same spots for the second trapping.

RESULTS

The numbers of different individuals taken (repeats not included) were as follows:

	DDT-treated area	*Check area*
Before spraying	40	27
After spraying	30	17
Percentage taken in second period	*75*	*63*

Fewer animals were taken in both areas during the second trapping period. The cause of this reduction in the size of catch may have been weather conditions, greater availability of natural foods at the later season, or other factors. However, since the reduction was similar in both areas, in fact greater in the check area, there is no indication from these data of injury to the Peromyscus population by the DDT treatment.

[1] Chitty, Dennis. Journ. Animal Ecol., 6: 36–53, 1937; Evans, F. C. Journ. Animal Ecol., 11: 182–197, 1942.

The number of animals marked in Period I and retaken in Period II can be compared for the two areas.

	DDT-treated area	*Check area*
Marked animals released in Period I (animals trapped minus animals that died in traps)	24	25
Marked animals retaken in Period II	11	5
Percentage of animals retaken in the second period	*46*	*20*

The percentage of marked animals retaken in the second period was greater in the treated area than in the check area. Numbers in each case are rather small, but there is no indication of harmful effects from the DDT application.

CONCLUSIONS

Measurement of the effect on the normal deer mouse population of an aerial application of 2 pounds of DDT per acre was made in a bottomland forest area on the Patuxent Research Refuge in May and June 1945. Amounts of DDT reaching ground level under the almost complete tree canopy averaged 0.05 pound per acre on the open forest floor and 0.008 pound per acre in areas protected by both trees and some form of ground cover.

The deer mouse population was exposed to DDT in the form of oil or crystals on vegetation and trees, and of DDT-killed insects. Both plant materials and insects are normal constituents of the deer mouse diet.

Possible effects on the deer mouse population were tested by a standardized method of live-trapping, marking, and releasing of animals in the area to be treated with DDT and in a check area, on May 2 to 7 and June 14 to 19. The DDT was applied on June 5.

Comparison of the numbers of animals taken in the two areas during the two trapping periods gave no evidence of any adverse change in the population as a result of the DDT application.

Because of the limited amount of DDT reaching the ground level, general conclusions concerning its effect on wild populations of deer mice or other small mammals require further studies.

UNIVERSITY OBJECTIVES IN PROFESSIONAL WILDLIFE TRAINING[1]

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In the earlier stages of a new program or when a new phase seems about to begin, there is some profit in considering objectives and means. With hundreds of students returning and with the country on the eve of a new day in wildlife management, as most of us believe, it is now appropriate to inquire how far the universities and colleges should go beyond their initial and necessarily opportunistic approach to the problem of training professional wildlife workers.

[1] Contribution from Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, American Wildlife Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri, cooperating.

We who are in college divisions of field biology have tried to meet immediate needs and overcome obstacles, among which are the scientific limitations of our subject. We have devoted much effort to professional training, not because professional students have sole claim on our attention, but because they represented the most urgent need in the situation. Also we have sought high standards; yet in this short time the quality of the professional training we offer has not yet risen to the level of that in some other fields.

The vocation of wildlife management has no strong supervisory body to set training standards, although the Wildlife Society is potentially such a body. Wildlife work has few of the economic connections that often determine standards; most of its values are to be reckoned in abstract terms. There has been little time for a professional philosophy to mature. In the states at least, wildlife conservation rests upon an inequitable financial base because, of all its beneficiaries, only the harvesters of wildlife contribute largely to its support. As a private enterprise it is still embryonic. All in all, the wonder is that it has gone so far in a decade or two. This is clear proof of intrinsic worth; but if it is to continue to grow into the life of our nation those who train its men have a growing responsibility. The goal is public acceptance, but acceptability must be proved and men must prove it.

Wildlife management may now constitute a profession. I think it does—hence the title of this paper—but its professional standing is not yet universally recognized. Even if both wildlife workers and the general public were to regard it as a profession, this alone would not make it one. A profession is an occupation involving special mental and other attainments or special disciplines. We are concerned here with the role of the colleges and universities in fostering the attainments and disciplines, intellectual, social, and personal, that the term "profession" connotes.

The goal of education is commonly considered to be the "good life," for both individual and community. When wildlife workers say, with Leigh Hunt, that they "may be content to know the earth by its fruits, but to increase and improve them is a more attractive study," they are indicating what they can contribute to the good life.

That contribution is fraught with difficulty. The wildlife worker must hold to an abstract purpose. His activities are limited by an anomalous situation: wildlife is public property in law, but not in actual fact. Like his colleagues in forestry and agriculture, he deals with a public that is often apathetic, prejudiced, and distrustful. In many instances he must reach his goal by other than scientific or economic means. When dealing with lands and waters, he usually plays second fiddle. Politics and accidents of residence figure too often in preferment. He meets some employers who do not know what training their men should require. Yet he is expected to get on with people, to know a great deal about all subjects familiar to his diversified clientele, and to perform a multiplicity of tasks with the patience of Job. For this his principal reward is the knowledge that he will never be rich or bored, and that his effort may help to per-

petuate the American tradition of a free outdoors. Manifestly, without some sort of working philosophy and a sense of humor, he is likely to flounder. The turnover on wildlife payrolls reflects this situation; at the same time it suggests that there might be greater stability if wildlife men were better oriented at the outset.

Let us then consider a few *problems* of training, from the nontechnical levels to the doctorate. These in turn will suggest *objectives.*

NON-TECHNICAL TRAINING

Sir Richard Livingstone, in his recent book "On education" (1945), mentions three classes: men of action, men of science and knowledge, and men of wisdom. These are not mutually exclusive. Some "science and knowledge" is needed on most "action" jobs as well as in research; and men of wisdom may come from any background. I should call a man of wisdom one who knows his place and that of his work in world history and behaves accordingly. Without such men at the top no great enterprise succeeds. There are degrees of wisdom and wisdom can grow, but it cannot be taught in college courses.

Men of action at the non-technical levels have received little from the educational institutions beyond occasional "short courses." In part this is because many university administrators appear to have a horror of "vocational training"—which is what these men need most. Such an attitude is understandable in a privately-endowed institution, but is difficult to reconcile in all cases with the tradition of service of a public institution to the state. The point is important here because nearly all wildlife training at present is in tax-supported schools concerned with both science and practical land use.

One need not suggest that all sorts of trade schools should be set up in the public universities. Where training is on an elementary manual level, the trade school certainly belongs apart. At least three arguments, however, suggest that vocational training in wildlife work belongs in the colleges and universities. Most of the information and skills needed by non-technical men are already taught at the college level. Few men would ever be enrolled—too few for schools of their own. Their training needs are so diverse that there would be even fewer in any single training program. In fact, most freshmen do not go on to degrees, so the admittance of a small, oriented, non-degree group would be unlikely to lower the tone of any student body.

In large part, however, this lack of attention to non-technical training results from off-campus causes. Most of these men are hired by state agencies and, where salaries are low and tenure depends upon the maintenance of political hegemony, good men cannot be expected to spend two years at college in preparation for non-technical positions. A system of non-technical training will therefore be effective only in states which offer respectable salaries and stable tenure. Both conditions are improving in some states, and there the universities should consider the demands to be made by these rising standards.

There is diversity in the fields of action for which these men are headed, but this does not alter the value of training and need not complicate the

program. Many standard college courses have practical value for all non-technical students—English, public speaking, identification of plants and animals, principles underlying the conservation program, and the like. For the special needs of each group there can also be less—formal instruction and apprentice work, with the cooperation of the state department. It is not entirely visionary to foresee the day when candidates for non-technical positions in the better wildlife agencies are given preference for having successfully completed some such course of training.

EXTENSION TRAINING

The universities also make extension courses available in many fields to employees and others who cannot attend regular classes but wish to improve their understanding and professional equipment. Only such institutions can do this on a large and continuing scale. In the field of wildlife conservation the only courses of which I know are two offered by the University of Missouri, in "principles" and in "practices." Despite the manifest shortcomings of any wildlife course taught by correspondence, the extent to which these two have been used makes us feel that such courses can fill a legitimate educational need. It would certainly be well for other institutions also to make the experiment.

THE UNDERGRADUATE PROGRAM

For undergraduates who seek degrees, the wildlife field is so diversified that the only feasible plan is to design one curriculum (or two, the second in aquatic biology) as though all degree students were potential men of science and knowledge, whether in research, management, or administration. There is little justification for more specialization during the undergraduate years.

It is also a responsibility of the training institution to try to develop leaders—the superior students who are most likely to become men of science and knowledge and men of wisdom. There are always too few leaders, and American educators have been roundly criticized for spending so much time with average students that the superior ones are left to shift for themselves. By and large the criticism is justified. There is little in the average university curriculum of today to tax superior minds. Besides teaching his courses well, however, a teacher can help to develop leaders by seeking them out individually; if they are worth stimulating they will respond.

In appraising undergraduate curricula I should like to use two terms employed in the Harvard Committee's "General Education in a Free Society" (1945): *Special education* is mostly in the area of concentration—in our field: zoology, botany, forestry, soils, and other studies closely related to wildlife work. *General education* lies mainly in other areas which for our purposes can be subdivided. Some, such as English, speech, political science, and most departments of agriculture, are "practical" for the wildlife student. The adviser has less difficulty in convincing the ambitious and realistic underclassman that he needs these than that he should expose himself to more "impractical" courses in the humanities, history, or the less pertinent branches of agriculture.

Why, indeed, *should* he take the

latter? Of what value to a wildlife man are "unrelated" subjects? The superficial answer is that they have no essential value. He could do many wildlife jobs without knowing anything about the other interests and activities of mankind. The wiser answer is that a man needs a personal philosophy, an awareness of his responsibility to his fellow-men; he needs a professional philosophy, an awareness of the responsibility of his work to the history of his nation. And unless he has interests far beyond one specialty he has not the makings of either one. The practical corollary is that a person who knows the course of the world and the way men think does his job more intelligently and hence more effectively than one who knows only the job.

These are the reasons why virtually all American universities have a dual educational objective. The duality does not refer to courses, because many so-called special courses have great general value, and the converse is true. Furthermore, the teacher, rather than the title or even the subject-matter, creates the value of a course. The dual objective is *education*, special and general. It seems to be agreed that the baccalaureate degree belongs only to a student who has made substantial progress along both lines. The undergraduate who seeks only to "specialize" should not expect a degree.

Nevertheless, an adviser in any field such as ours, which requires many knowledges and skills, sometimes finds himself in a difficult position. The average undergraduate would like to specialize as soon and as much as possible. Since his prospective employer also is likely to be more interested in the result of special rather than general education, the result is double pressure to allow the student to take every course obviously related to wildlife work while he is still an undergraduate, whether or not he is intellectually or socially ready to do so. The adviser can assent, which is the easiest course; or he can hold his ground and blame the Dean; or he can make an honest attempt to show the critical student the value of a dual objective. The last is often difficult, sometimes fruitless, but wisest in the end.

Meanwhile two groups are coming to the aid of the harassed adviser who believes in a proper balance between special and general education. One is the growing number of young men who are making good in wildlife work despite a goodly share of general education. They exemplify the axiom that the horizon of a leader in any field extends far beyond its limits. The other is the growing number of far-sighted employers interested in hiring men who have done something besides learn a trade, who can talk something besides "shop," and who can meet people in all walks of life with ease.

Finally, we cannot afford to overlook the fact that wildlife work is a small field in the economy of our nation. There may be an upswing in the demand for workers during the next few years, but as a rule good jobs will be fewer than the students who seek them. This is the best practical reason for emphasizing quality rather than quantity in schooling for wildlife work.

THE MASTER'S PROGRAM

No sharp boundary is crossed on Commencement Day. The professional

student goes from a curriculum in which general education is gradually replaced by special education into one which embraces only the latter, but the transition is not abrupt. The fifth year in many fields—forestry, journalism, engineering, and our own—is coming to be more closely knit to the first four. The statement on wildlife curricula at the University of Missouri reads, "It is held at this institution that while a student may prepare himself during the eight undergraduate semesters for some types of professional wildlife work in their early stages, his progress toward the larger responsibilities in this field requires at least a year of graduate work . . . . For this reason both the General Curriculum and the Fisheries Curriculum are prepared on a five-year basis."

Nearly all graduate work in the wildlife field heretofore has been at the level of the Master's degree, and while requirements for this degree vary greatly the country over there are certain essentials that are not difficult to rationalize. Seashore (Three-way organization in the graduate school, Journ. Higher Educ., 15, 1944) mentions three sorts of program: "(a) the Standard plan, specifically designed for the maintenance of liberal and rigorous standards leading to the traditional advanced degrees, (b) the Terminal plan, providing for specially designed terminal schedules leading to the master's degree and (c) The Free-lance plan, not leading to any degree." Wildlife work has a place for all three. Most graduate students of wildlife, however, expect the master's degree to end their formal training.

We need therefore to consider most carefully the objectives of a terminal plan. One function clearly is to fill gaps in the upperclass portion of the student's special education, and this is the general policy in all graduate schools. Certainly no student with the bachelor's degree in such a diversified field as ours is likely to be without such gaps, and they are most conspicuous in the records of students entering wildlife curricula from other majors or other schools. Many "transfers" have even to fill underclass gaps without graduate credit.

A second function is suggested by the existence of some courses which belong only in the graduate school. Probably no one will disavow this general principle, although there may be disagreement over the placing of any specific course. On the whole, it seems logical to presume that the most advanced and professionally-oriented courses should be near the apex of the training program and not scattered throughout where they would be studied superficially or by unprepared minds. If such is the case, management courses and some others belong in the apical group.

Research is important in the first graduate year, not only for its own sake and for the use that can be made of the results, but also to develop the student's ability to solve field problems and present his results in cogent fashion. The new graduate is seldom a capable independent investigator, and much of his early research may have to be observational rather than analytical or experimental. Nevertheless he should be given a start, and what he does will often disclose aspects of his makeup that are of professional significance.

This brings to mind the unfortunate fact that the spoken and written Eng-

lish of students—even of graduate students—is seldom all that it should be. It is a waste of energy to blame the departments of English or the secondary schools for the result of a public attitude. Supervision of student use of English by all teachers should be as automatic as supervision of any other activity. The effect may bring credit to the students and relief to their employers.

Finally, there is the variety of useful functions served by seminars, special studies, and other minor components of the curriculum, in the major department or elsewhere.

THE DOCTORAL PROGRAM

It is generally agreed that the student encouraged to go beyond the Master's degree must have shown, first and foremost, intellectual promise of a very high order, plus apparent ability in independent endeavor. He represents a substantial investment in time, money, and effort. Therefore he should be prepared to do and should perform the most original, fundamental, and highly technical work of which he is capable, leaving purely descriptive research largely to others. This implies a qualitative as well as a quantitative difference between his accomplishments toward the doctorate and those at the lower levels of his training.

So far, only a few holders of the Ph.D. have gone into wildlife research and management. There are several reasons why more should do so. The most urgent is that the doctoral program is the best, though not the only, proving ground for scientific leaders. Prior to the age at which they embark upon work for the doctorate, most students have not approached intellectual maturity. Too often, then, a potential leader has little chance to "try his wings" at a high level before he goes to a position in which there is little incentive to do so.

Another reason is that the Ph.D program is the best proving ground for investigators in the basic scientific fields which are at the foundation of wildlife management. There is a need for long-term, well-paying fellowships at the doctoral or even postdoctoral level, filled by men ready for professional work.

During his doctoral training, the candidate should come as close as possible to mastery of some one established scientific field, with strong "minors" in related fields. To me this means there is little virtue in setting up a doctoral program in wildlife management as such, for this is far from a well-defined area. Rather, the candidate should experience rigorous discipline in zoology, botany, or forestry, with his research on a problem involving wildlife and only secondarily, if at all, involving the application of research results to practical management. His foremost contribution should be basic information. Its applications can be more effectively tested, on a larger scale, by state and federal agencies. Superficially, the scientific problems of wildlife management appear distinct from those in the older branches of biology, but the more deeply one goes into them the greater appears the need for recourse to the data and disciplines of the parent fields.

This also is the period when a young man who is being groomed for a position of major responsibility to society—and who realizes the possibilities of his

future—should be enlarging his equipment, extending his horizons, and exercising the rational and imaginative uses of his mind while he can still do so under guidance. He will round out his training through more advanced courses. Perhaps he will visit other classes from which he seeks no credit (a practice made far too difficult at many institutions). If necessary, he will spend terms or semesters at other schools which have facilities that his own lacks. Even more important is his intimate, protracted contact with faculty members who, as Aldo Leopold has said, are attempting to fit him to outscore them on all possible counts.

THE STUDENT'S RESPONSIBILITY

The reader has perhaps been wondering whether *only* academic and intellectual standards are considered important in wildlife training. Far from it. No educative process should be one-sided, either as between teacher and student or as between the mind and what may be broadly called the character. In justice to the student and to the profession for which he is being trained, both mind and character must be considered from the freshman year on. (Indeed, the value of "catching 'em young" is nowhere better illustrated.)

The student has certain clear obligations in his own interest: to realize that his personal and social attributes are as important to success as his intellectual competence; to play an *active* role in his overall development; to appraise himself frequently and objectively; and to build a personal philosophy. In all of these the teacher can help, but can only help.

How is this done? There are many influences which good teachers use unconsciously, but the best conscious teaching instrument is personal example. "Preaching" alone will not do. A student can be told again and again that good English and a scientific attitude are assets, but he is not impressed if those who tell him use poor English or display emotional bias. Personal example is the most difficult and subtle of all educational tools, but if students are to be encouraged to develop the characteristics which their older associates believe are essential to success, they must have before them what Professor Whitehead has called "the habitual vision of greatness," without which "moral education is impossible."

The reader must not misinterpret this allusion. Few of us are great or ever will be. The nearest most of us will ever come to greatness is by *trying* to be what we should like our students to be. Even then, the student may not comprehend or, comprehending, may do nothing.

There is no need to enumerate the familiar traits which are looked for in an integrated man of high character. It is necessary only to say that by virtue of the student's position as a selected individual, society has the right to expect in him traits of character much above the average; and few of these are taught in courses.

By saying that the student must participate actively in his own education, I do not mean simply that he must do the tasks assigned; any workhorse can do that. Rather, he must assume the role of partner in an enterprise that is for his own good. Teaching is not pouring; to be effective it requires *two* receptive and cooperative minds. The

initial establishment of receptivity may be in part the duty of the teacher, but its maintenance is the responsibility of the student. Strangely enough, many students have to be convinced that they come to school to learn, not to be taught.

Here is an illustration: The serious student expects to acquire a good deal of knowledge, even technical knowledge, apart from his courses. Yet some, I regret to say, seem to take the vulnerable position indicated by an embarrassing episode in my own graduate-school days, now more than twenty years past. I excused my ignorance of a certain subject by telling my major professor that I had never had a course in it. He pointed his Van Dyke beard at me and said, "Mr. Bennitt, do you cherish the illusion that you are not expected to know anything unless you have had a course in it?"

Concerning self-appraisal, this should become a habit, provided it can be done objectively and without undue discouragement. Usually it is an informal and highly personal process, but there is at least one formal instrument of self-appraisal—the Graduate Record Examination. Whether a wildlife student makes use of this is his own decision. It is administered in sixty-odd American institutions, in few of which there is formal wildlife training in progress, but anyone may take the examination. Last year I found it to be an exacting intellectual experience, and I believe it will appeal to any student interested in knowing his strengths and weaknesses.

The final responsibility of the student, in which the teacher can assist but not compel, is the development of a personal and professional philosophy. How this is done I do not know; but somehow or other the best teachers seem to stimulate it.

* * *

All this leaves us with certain direct or inferential conclusions regarding the objectives of colleges and universities in professional wildlife training. The field is broad. Comprehensive training must extend far beyond wildlife courses, beyond the conventional major in biology, and usually beyond the bounds of any administrative or subject-matter division. A full training program can be undertaken successfully only at an institution where the requisite variety of interests exists. Such a program is an excellent example of the modern correlative study which transgresses departmental and divisional barriers and comes nearer to education than many older and more compartmentalized programs.

There should be no sharp lines of demarcation, either between fields or between academic-professional levels. The curriculum should be both unified and graded to fit growing minds and characters whose growth is a function of the teacher-student partnership.

Baccalaureate training should embrace both special and general education, the latter through both "practical" and "impractical" studies. Imaginative and world-minded men are needed who know more than their jobs and are developing the makings of wisdom.

A guiding principle in wildlife research must be Aristotle's dictum: "It is a mark of an educated man to seek only as much exactness in each type of inquiry as may be allowed by the nature

of the subject matter." Within these limits, wildlife research should grow away from the purely observational and toward the fundamental, analytical, and experimental. One may hope that the results of research will be useful, although some of the most essential research has no immediate practical utility. On the other hand, there is no important scientific development that is not founded on basic research.

Personal and social attributes are as important to success in this field as intellectual attainments. Their development is the primary responsibility of the student, but his teachers can help.

The omission from this paper of any comments on training in administration suggests the writer's view that good administrators, like good teachers, become so by knowing their subjects and possessing certain personal attributes—not by taking courses in this specialty.

University training should "screen" both upward and downward; it should discover both potential leaders and potential failures. Because there will always be relatively few jobs, it should emphasize quality, not quantity.

Perhaps these standards are already universally accepted in both theory and practice. If I thought so I should not have written this paper. Once they *are* in practice they will, I believe, leaven both the training institutions and the whole conservation program.

MULTIFLORA ROSE FOR FARM HEDGES

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The need for a low cost barrier to protect farm woodland and wildlife areas against livestock became apparent early in the history of erosion control plantings by the Soil Conservation Service. Many of these plantings were confined to gullies or other small and irregular areas which could be protected with conventional fence only at exorbitant cost. A living hedge or fence appeared to be the logical answer. *Rosa multiflora*, commonly referred to as multiflora (many-flowered) rose, has been tested in Missouri and Illinois, and shows considerable merit for such use (Pl. 15). Indeed, the prospects of multiflora rose hedge as a general field divider far outweigh its potential as a barrier for woodland and wildlife areas. Since an earlier discussion of the species as a farm hedge (11), additional observations warrant a further report.

The natural selection for a living fence would be osage orange (*Maclura pomifera*). This tree came into widespread use on the prairie as a farm hedge in the middle of the last century, after countless trials with other species by prairie settlers (1, 7, 8). It was the one species that met with success and was the standard prairie fence until the development of woven and barbed wire. But osage orange, also known as bois d'arc or "hedge," is unsatisfactory under modern farming conditions for several reasons. It is difficult to main-

tain a livestock barrier with osage orange unless the hedge is kept clipped and otherwise trained. The early hedges were trained by an ingenious system called plashing (4, 9). The untrimmed hedge suppresses adjacent crops to the extent that is objectionable to the Midwest farmer. The benefits in terms of wind protection to the field, fence post production, and wildlife cover do not overcome this objection. The thorns puncture pneumatic tractor tires and this has increased opposition to the species as a field border. The fundamental weakness of osage orange, however, is its incompatability with present day degraded soil profiles. Sturdy old hedges are common on sites where new plantings make practically no growth; this is best explained by the fact that the old hedges were planted when the soil was nearly virgin. Indeed, widespread tillage of the prairies was not possible until the middle of the last century when osage orange was introduced—wire fence had not been invented and there was no other practical means of protecting prairie fields against roaming livestock (8).

In an attempt to find a suitable plant to replace osage orange, the woody plants adapted to the region were canvassed by members of the Soil Conservation Service nursery division in the Upper Mississippi Valley. Initial trials of plants widely selected from native and introduced sources were made at the Elsberry, Missouri, SCS nursery; subsequent tests of conspicuous species and varieties were made on 30 distinct problem areas in Missouri and Illinois. The Asiatic *Rosa multiflora* was outstanding in all these examinations and tests. Subsequently it has been subjected to widespread trial as a living fence under actual farm conditions. The oldest fence plantings were made in 1940. Tests to determine barrier effect with all kinds of common livestock were made in 1943 and 1944, using fences of various ages and spacings. The response of the species under a variety of site conditions and cultural treatments has likewise been observed.

CHARACTERISTICS

Multiflora rose is a vigorous shrub with long arching or reclining branches and dense twigs. It is native to Japan, Korea, and parts of China. Under average conditions of growth it attains a height and breadth of about 8 feet. It is generally considered hardy to the northern boundary of Missouri, the central parts of Illinois and Indiana, and throughout Ohio. Yet there are numerous old plantings much farther north. Even at Brookings, South Dakota, the species persists and makes vigorous growth, although many branches kill back (6).

As the name indicates, it bears a mass of small white flowers with as many as 200 blossoms on one panicle. The flowers are followed by masses of fruits, the size of small peas, which turn red and persist through the winter or until consumed by birds.

Multiflora rose is used in great quantities by the horticultural trade as a common understock for garden roses. The strain generally employed is thornless, hence not suitable for fencing. The species is variable and has given a host of sports and distinct seedlings (10). This variation in progeny suggests the possibility of selecting a strain with even better barrier characteristics than

A
B

the common seedling type.

Roses generally are subject to numerous diseases and pests, such as leaf spot, mildew and rusts, scale insects, leaf miners, and others. No serious insect pests have been observed to attack multiflora rose but various diseases, and common leaf eaters such as grasshoppers, cause some defoliation by late summer. Multiflora rose is much less subject to foliage diseases than its nearest native counterpart, the prairie rose (*Rosa setigera*).

A question often raised is whether multiflora rose will spread by suckering, layering, or seeding; it does not sucker and does not propagate by layering but, like most woody plants, will layer if a branch is covered by soil for some time. Seedling regeneration does occur under favorable conditions but not to the extent of constituting a nuisance.

SITE AND CULTURAL REQUIREMENTS

Since 1939, plantings of multiflora rose have been made on almost all soil types, degrees of erosion, aspects, and exposures common on farmlands of Missouri and southern Illinois. A variety of cultural treatments likewise has been tested. The species has wide edaphic limits and has been the outstanding shrub in trials of wildlife shrubs in the area. Its growth performance is best on deep, fertile, well-drained but moist uplands or bottomlands. On relatively adverse sites such as eroded claypans of central Missouri and southern Illinois, growth has been fair to good and outstanding in comparison with other planted shrubs, native or exotic. Growth has been poorest where the topsoil has been removed entirely and where the subsoil is an impervious drab plastic clay, or where the other extreme of a droughty blow-sand is encountered. On such adverse sites it is doubtful if a barrier can be achieved with multiflora rose, regardless of culture.

During at least the first 4 or 5 years, multiflora rose has been more vigorous than osage orange under all site conditions. On many fairly adverse sites, multiflora rose has attained barrier dimensions in 4 to 6 years, when osage orange has made practically no growth. Plantings have done well on all aspects and at various degrees of exposure.

The plants respond markedly to sup-

PLATE 15

Multiflora rose. *A*. Contour fence in second year of growth (farm of John Priest, Jackson, Missouri). Hedge is already an erosion buffer. The soil was so badly eroded that the field had once been abandoned, but such lower horizons (Loring silt loam, a loess) are favorable for woody plant growth. *B*. The masses of bloom are followed by small, red hips which persist throughout the winter or until consumed by birds. *C*. Four-year rose fence on contour, Elsberry, Missouri. The soil is severely eroded clay loam (Ava series), but the planting has been benefited by concentrating the thin topsoil along the planting line through back-furrowing, and mulching with old straw when set out. *D*. Plants 12 to 15 years old at Missouri Botanical Gardens near Gray Summit. They were spaced 6 to 8 feet apart, but the barrier effect of such plants close-spaced in a single row can be visualized. Note that this rose does not have the habit of spreading.

pression of competition during establishment. On the better soils, cultivation for the first year or two to suppress herbaceous vegetation is particularly beneficial. On the field side of the fence, current farming operations of seedbed preparation, cultivating, and mowing are effective in reducing competition. Mulching, where heavy enough to suppress most weeds and grasses, has been consistently superior to cultivation. Growth has been weak where the soil is already occupied by roots of established trees. The likelihood of ultimate overtopping and suppression by adjacent trees would indicate that a rose barrier should be at least one rod from the nearest trees in a woodland plantation.

The vigor of the species on poor soils suggests low fertility requirements and, in fact, fertilizer applications have been only moderately beneficial. Numerous plots were fertilized in 1941 with as much as one-fourth pound of 4–16–4 fertilizer worked into the bottom of the planting hole. That summer was very dry across all of Missouri and southern Illinois, and the heavier applications resulted in heavy loss of plants. One- and two-ounce applications of 4-16-4 in subsequent years have been moderately beneficial on infertile soils. Applications of strawy manure have been beneficial on poor sites, but showed little benefit on good soils and even compared unfavorably with a mulch of straw, weeds, or similar refuse. Manure applied to the planting site prior to plowing appears to be beneficial. Fences bordering several fields on the same farm appear to be somewhat stimulated where adjacent to legume fields, and there is an indication that fences adjacent to black locust plantings are invigorated.

Clipping and pruning tests have been made with multiflora rose fences of various ages. The plant recovers vigorously from severe cutting-back, but there appears to be no need for trimming or pruning in managing multiflora fences. This is a cardinal advantage of multiflora over osage orange.

METHOD OF PLANTING

A number of spacing arrangements and planting methods have been tried in establishing a barrier with multiflora rose. Single rows with the plants 3 and 4 feet apart were first used, and staggered double and triple rows of various spacings have been tried. Those made during the last three years, however, have been mostly single rows with the plants spaced 12 inches apart. This interval appears necessary to assure a tight barrier within a few years. The single row also is easier to establish and consumes less space. This spacing was used with the osage orange hedges after the culture of that plant had reached its highest development.

In establishing the osage orange hedges during the last century, the site was prepared by back-furrowing and then bed-furrowing so that the plants were set on a slight ridge of deep and well prepared topsoil. The extra effort involved in such preparation is offset by the ease of planting in prepared soil. Early growth moreover is enhanced markedly by such soil preparation. The old hedge planters achieved a rate of 3,000 to 4,000 plants per man-day (4), and rose seedlings can be dibbled in at almost this rate.

Various methods of planting with

team and tractor plows have been tried but have been inferior in both quality and speed to hand planting in a prepared ridge.

BARRIER PROPERTIES

Livestock tests with multiflora fence thus far have been confined to the Soil Conservation Service nursery at Elsberry, Missouri. Paddocks have been arranged, using sectors of rose hedge for one or two sides and conventional wire fencing for the others. The sectors of rose have been at least 200 feet in length. Hedges 3 to 5 years old and at various spacings on both hills and bottomland have been tested with cows, young calves, horses, sheep, goats and hogs.

The older hedges in these tests were planted at 3- and 4-foot spacings, and at 1- and 2-foot intervals in the younger fences. All plantings received fair to good maintenance. The soil quality of the fence locations varied from choice accreted bottomland (Lintonia silt loam) to severely eroded loess upland (Ava silt loam). Livestock tests were made by confining the various kinds of animals in the paddocks for 2 to 10 weeks. During these tests, their normal rations were reduced at times to encourage the stock to break out in search of forage.

These tests indicated high barrier qualities for a tight, properly developed multiflora hedge. Horses, cows, and calves were confined by all barriers tested. Sheep and goats usually were confined, but were apt to find openings in the 3- and 4-foot spacings after several days or weeks. These animals browsed the foliage but only the tips of the branches, because the remainder of the plant was well protected by thorns. Hogs proved the most difficult to hold because of their ability, when not ringed, to root under the arching branches and take advantage of low openings between widely spaced plants. Brood sows and shoats were confined for several days by 4- and 5-year hedges with plants spaced 3 and 4 feet apart.

Thus a close-spaced, properly developed hedge of multiflora rose may confine all common farm animals (probably not poultry) after 4 or 5 years. The importance of spacing plants closely (12 inches apart) in a single row is indicated by these tests, as is the need for careful site preparation, planting, and management during the first two or three years.

GENERAL FARM FENCE

Since the earlier conception of a living fence for protecting woodland and wildlife areas, numerous multiflora plantings have been made to divide farm fields. Multiflora hedge appears to have special value as a divider between fields farmed on the contour, where it also serves as a contour guide and a buffer band against erosion. It is difficult to construct a satisfactory wire fence on a contour because of the lateral stresses on line posts.

American farm fences are of large significance economically. The steel drawn into fence wire each year would build a dozen battleships. The cost of this wire, not to mention the value of the 400,000,000 fence posts used annually or the staples and labor required in fence construction and maintenance, about equals the total value of all stumpage sold yearly in the United States (11).

WILDLIFE VALUE OF LIVING FENCES

Shrubby field borders have recently come into high esteem by wildlife managers. Edmister found that fields with hedges supported 60 per cent more pheasants than those without hedges (5). In Ohio there are 32 times as many songbirds in shrubby fence rows as in open crop fields, according to Dambach (3), who writes: "in the agricultural sections of Ohio and Indiana, the amount and distribution of fence-row vegetation probably affects farm wildlife more than any other factor."

Managed woody or perennial vegetation is recognized as an efficient means of displacing the usual weed growth. The dense character of multiflora rose is especially effective in suppressing weeds.

Woody vegetation along fence rows apparently contributes to pest control. Unpublished studies by the Missouri Wildlife Research Unit indicate a lessened population of chinch bugs and grasshoppers in fields bordered by shrubby growth due to the high songbird population made possible by the cover. A 4-year study by W. P. Flint of Illinois showed similar relationships for clean farmed areas as compared with those bordered by well-protected woody vegetation. Insect damage was definitely reduced where shelter existed for songbirds and parasitic insects. Quite obviously the biologic balance upset by clean farming tends to be restored by field borders.

In a songbird survey by Harry G. Anderson of Illinois Natural History Survey, multiflora rose was found superior for songbird nesting cover on the Elsberry nursery. Of the hundreds of trees, shrubs and vines introduced, this rose was outstanding in the variety and numbers of bird species which used it for nesting. It also provides ideal winter cover for songbirds. At Elsberry, cottontail rabbits make intensive use of clumps of multiflora rose for cover, and both quail and pheasants use its cover, in winter and summer. A dense clump of multiflora cannot be penetrated by dogs; hence the species has value as escape cover.

The abundant hips of multiflora are eaten by songbirds in the winter and early spring; a common observation illustrates the extent of this use. Old bird nests within thickets of multiflora accumulate seeds, free of other fruit parts, until the nests became rounded with the relatively cleaned seeds. This observation was baffling until overwintering birds were seen to carry panicles of fruits to the nests which served as "tables" where the fleshy parts of the fruits could be consumed safely. Usually a small hole also is opened in the seed-coat and the seed contents removed also. Quail and rabbits make winter use of the fruits. Utilization of the bark and young stems by rabbits is usually inconspicuous, but was pronounced in one instance where a dearth of other food existed.

Van Dersal (12) points out that the fruits of the genus *Rosa* are imporant to a variety of birds and animals as a reserve food and for grit.

PROPAGATING AND HANDLING PLANTING STOCK

Stock of multiflora rose for planting is readily grown from seed in one year. The characteristic of the parent plant to produce masses of fruits, each containing 6 to 12 seeds, makes seed col-

lection simple. In 1941, the Elsberry nursery produced 400,000 plants from seed gathered the previous autumn about 30 bushes planted on the nursery grounds in 1937. There are usually 60,000 to 70,000 cleaned seeds per pound. In the 8 years the writer has been observing multiflora rose in Missouri, it has never failed to produce a full crop of fruits annually.

The seeds germinate readily following an after-ripening period of 60 days at a few degrees above freezing (2). After-ripening may be obtained by stratification in cold storage about February 1 for sowing about April 1 (at the latitude of Elsberry) or by late autumn. Germination occurs promptly early in spring in a cool seedbed, but is unsatisfactory if sowing is delayed until late spring. Good seedbed preparation, sowing, and management are needed. Seedling densities should correspond to those of black locust or green ash.

Multiflora rose is one of the easiest species to transplant, and good stock can be moved with minimum loss *if handled while dormant.* The species breaks dormancy very early in the spring and remains in leaf late in the autumn, hence the successful planting period is limited. Best results have been obtained in late autumn with mulching, or by planting very early in spring.

Some remarkable survival results have been secured with proper practice. Two fences were planted in December 1941, on farms near Jackson, Missouri, each being over one-half mile in length. No replanting was required except where terraces were later cut through the fence. Of 177 plants in a fence planting at Elsberry in the spring of 1940, only two plants were missing 4 years later. If set out after the plants are in full leaf, however, losses exceeding 50 per cent may occur, even where planting practice is otherwise of high quality.

SUMMARY

Rosa multiflora, the multiflora rose, has been tested as a living farm fence in the southern Upper Mississippi Valley for several years. It appears of value for protecting woodland and wildlife areas from livestock, and is of even more potential value to divide farm fields. Such fence provides fine nesting, escape, and travel cover for wildlife, and the abundant persistent fruits afford winter food and grit.

The many objections to osage orange and its inability to make satisfactory growth on present-day degraded soil profiles, renders this once standard hedge plant unacceptable to farmers. Unlike osage orange, multiflora rose is a shrub, hence it occupies much less ground. It attains an ultimate height and spread of about 8 feet, requires no trimming to keep it in bounds, and, unlike osage orange, offers little competition to adjacent crops. Its vigor, particularly on the poorer soils, greatly surpasses that of osage orange. Multiflora rose is colorful in flower, foliage, and fruit.

This rose appears to have special value as a divider between fields farmed on the contour where it serves as a fence, a contour guide, and an erosion buffer strip. Living fences are better adapted than wire fences for contour planting.

One-year seedlings of multiflora rose seem best for planting; they can be produced readily in a nursery, at about

the cost of black locust seedlings. For fence plantings, a single row with the plants spaced 12 inches apart is recommended. Planting is speeded and growth enhanced by preparation of a slight ridge formed by back-furrowing and discing a planting strip 8 to 10 feet wide. Suppression of competition by mulching or by cultivation during the establishment period will greatly hasten the formation of a barrier.

Multiflora rose is adapted to a wide variety of soils and situations, but will probably not form a barrier on badly eroded claypans or drouthy sands and gravels. Fertilization has been of little advantage.

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SNARES AND DEADFALLS

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A knowledge of primitive animal traps can be of great value to the wildlife biologist, as to all outdoorsmen. Not only can such knowledge be used to secure food when necessary to live outdoors without equipment, but it can be put to more immediate use in several other ways. Field men are better able to talk with backwoods trappers if they are proficient in operating wilderness traps. In some studies that involve trapping, the snares and deadfalls may provide ways of taking specimens with less damage to the skins and with more food in the digestive tract than if the slower-killing steel traps are used. Furthermore, the materials for construction of snares and deadfalls are found in the field or are easily carried in the pocket. Such devices can be constructed with

little effort, even on occasions when promising animal signs are encountered unexpectedly. Primarily, however, these devices are described here to preserve a record of them as indisputably ingenious backwoods inventions; some now are rarely seen and nearly all are more humane than steel traps.

A few of the devices were conceived by the author and several were observed in various parts of the country, but plans for most of them were collected while he was instructing Navy fliers in ways to live off the land if forced down. Part of this survival course was devoted to construction of snares and deadfalls in the field. At the close of instruction, the students were invited to add to the collection of wilderness traps demonstrated. In this way, over a period of two and a half years, backwoods devices from all over the country were encountered, but after the first year only one new type was so discovered. It is thought that most of the snares and deadfalls in common use have been pictured. All of them can be modified in size and arrangement, and can frequently be used in combination.

The photographs reproduced herewith (Pls. 16–19) had to be arranged by shape rather than subject, but the text attempts to classify the various traps in a more logical manner. Text numbers refer to photographs on the plates.

SNARES

Animal traps that catch or kill an animal by means of a noose or sprung sapling are included in this heading. The nooses and trip-strings shown were made especially obvious in the photographs, but ordinarily they should be as nearly invisible as possible. Thin, inconspicuous flexible wire is best for snares, although dark cord or even horsehair sometimes can be used. If no string or wire is available, a line can be twisted from threads, leaf fibers or the tough, inner bark of basswood, mulberry, elm, leatherwood and other plants (see Craighead and Craighead, 1943). The noose should be made by first tying a small bowline or other loop that will not slip into the end of the line, and then passing the line back through that loop (see photographs). An ordinary slip knot might bind, enabling the animal to escape.

SNARES WITHOUT SAPLINGS

Simple fixed nooses are effective in the runways of rabbits and some other animals. In travelling along the trail, the animal becomes entangled in the noose and chokes itself to death while trying to get free. These snares are quickly and easily set but game caught is in a position to be eaten by predators.

2. Fixed snare attached to a stick lodged above a runway.

3. Rock-flip snare. Where saplings are absent, a weight can be made to throw a runway noose tightly around the animal's neck.

10. Fixed snare staked by a runway.

RUNWAY SAPLING SNARES

These traps are set across game trails and at the log crossings and dens of many animals. Such snares are not baited but catch the animal when it inadvertently runs into an inconspicuous noose or trip-string across the runway. This action disengages a trigger, allowing a trimmed sapling to swing the animal in the air or to disable it otherwise. Where no sapling is growing in

the proper place, a peg may be driven into the ground and then removed. A cut sapling placed in such a hole will function perfectly. In most of the photographs only the trigger and noose are shown; the sapling must be visualized as attached to the taut vertical cord or wire.

4. Notched peg snare. An animal running into the noose disengages the notched sticks. To be most effective: (a) both notches should be V-shaped so that the points of the V rest upon one another, and (b) the noose should be tied to the top of the movable peg while the sapling cord is secured to its bottom so that maximum leverage is provided.

6. Two-peg snare. The notches in the vertical stakes should be cut to V points and the ends of the horizontal peg should be pointed. Best leverage is gained if the sapling cord is tied at one end of the cross-piece and the noose at the other.

8. Arrow snare. When the high, taut string (white) in the photograph is struck by a passing animal, the horizontal bait stick of the letter-A type trigger (nos. 7 and 9) is removed. The sapling, taking up the slack (black) line attached to the arrow (in forks, at the left) drives the shaft into the animal with great force.

11. Single-loop snare. A simple trigger, but difficult to set.

12. Slip-knot snare. Make a slip knot in the line and place the overhand twist of the loose knot (not the end loop) over the stake and tighten. This is simple, easy to set, and sensitive.

14. Treadle snare. An animal stepping on the treadle of twigs (ordinarily covered with dead leaves) pushes down the cross-stick, releasing the sapling and its leg becomes caught; this type is especially useful, enlarged, for deer and other large herbivores.

29. Knife snare. A large sapling lashed upside down to a tree bears a wooden or metal knife. An animal tripping the vine at the lower left of the picture pulls the ring off the trigger. This releases the knife which delivers a terrific blow (see nos. 30 and 31).

30. Knife snare trigger in more detail. (Compare no. 31.)

31. Knife snare. Model of a simplified trigger arrangement; the lower cord is the trip-string.

32. Leg-breaker snare. An animal hitting the trigger string, which is hooked by a notched stick caught on a sharpened stake (foreground of the picture), releases a powerful sapling held at its base between two trees. Dangerous to human beings.

33. Bow and arrow snare. With a trigger as in no. 32. A seasoned bow is essential. The trip-string runs beyond the lower right of the photograph.

BAITED SAPLING SNARES

Baited snares are useful where sign, particularly of carnivorous animals, is common but no runways are present. To increase the probability of a catch, animal intestines can be dragged along routes leading to the traps; the use of scents also is often helpful. Baits should be tied securely to the trigger sticks.

1. A baited snare set for raccoons.

5. Notched-peg snare modified to catch an animal by the leg or leg and head.

7. Letter-A snare. One of the most practical snare triggers. The sapling (white cord) held down by the short vertical stick is released when the baited

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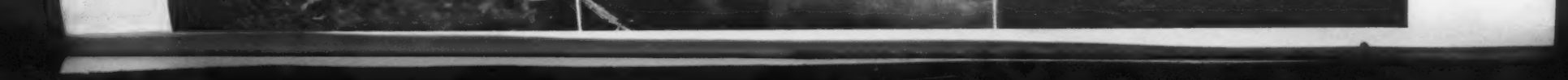

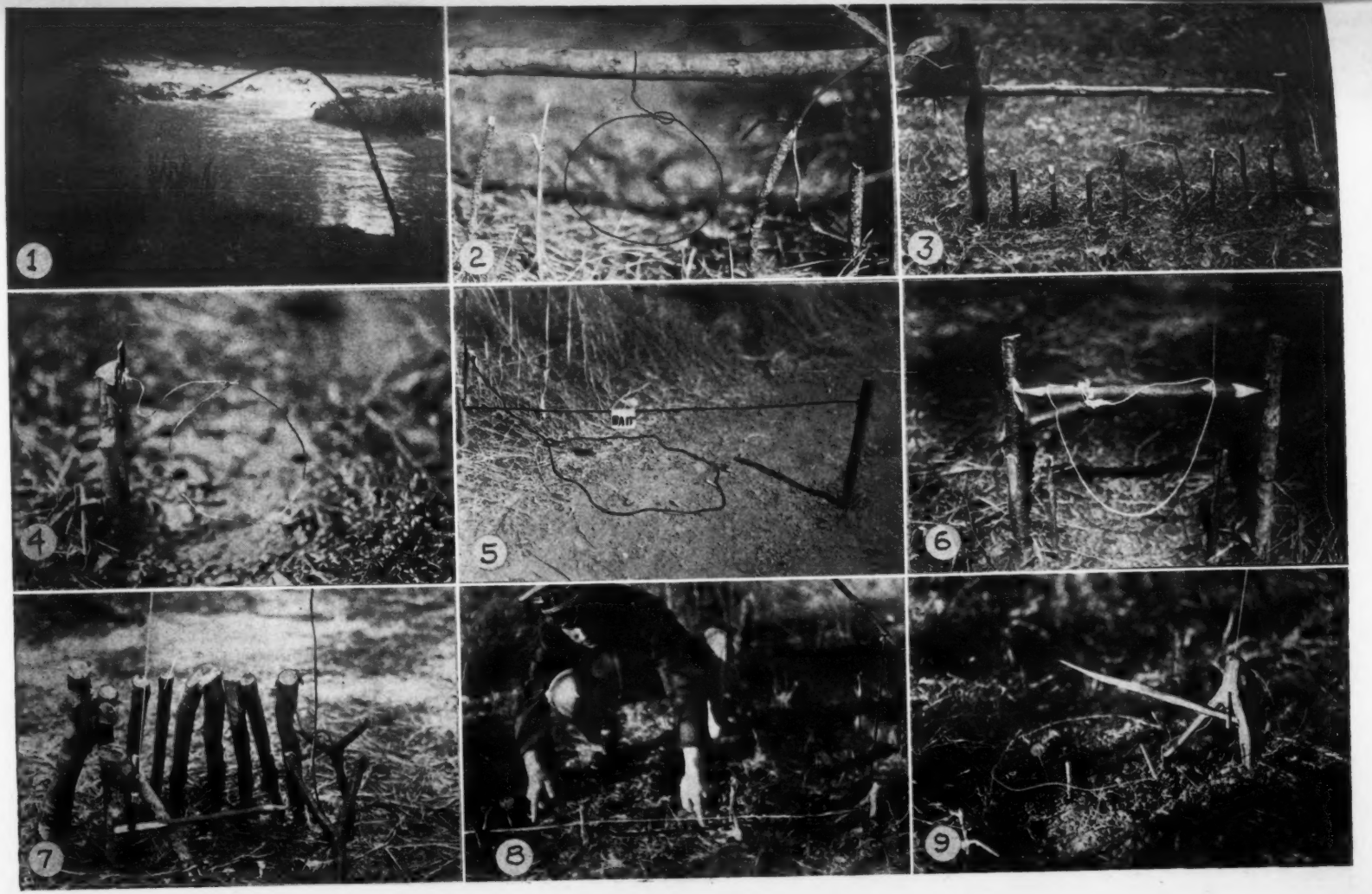
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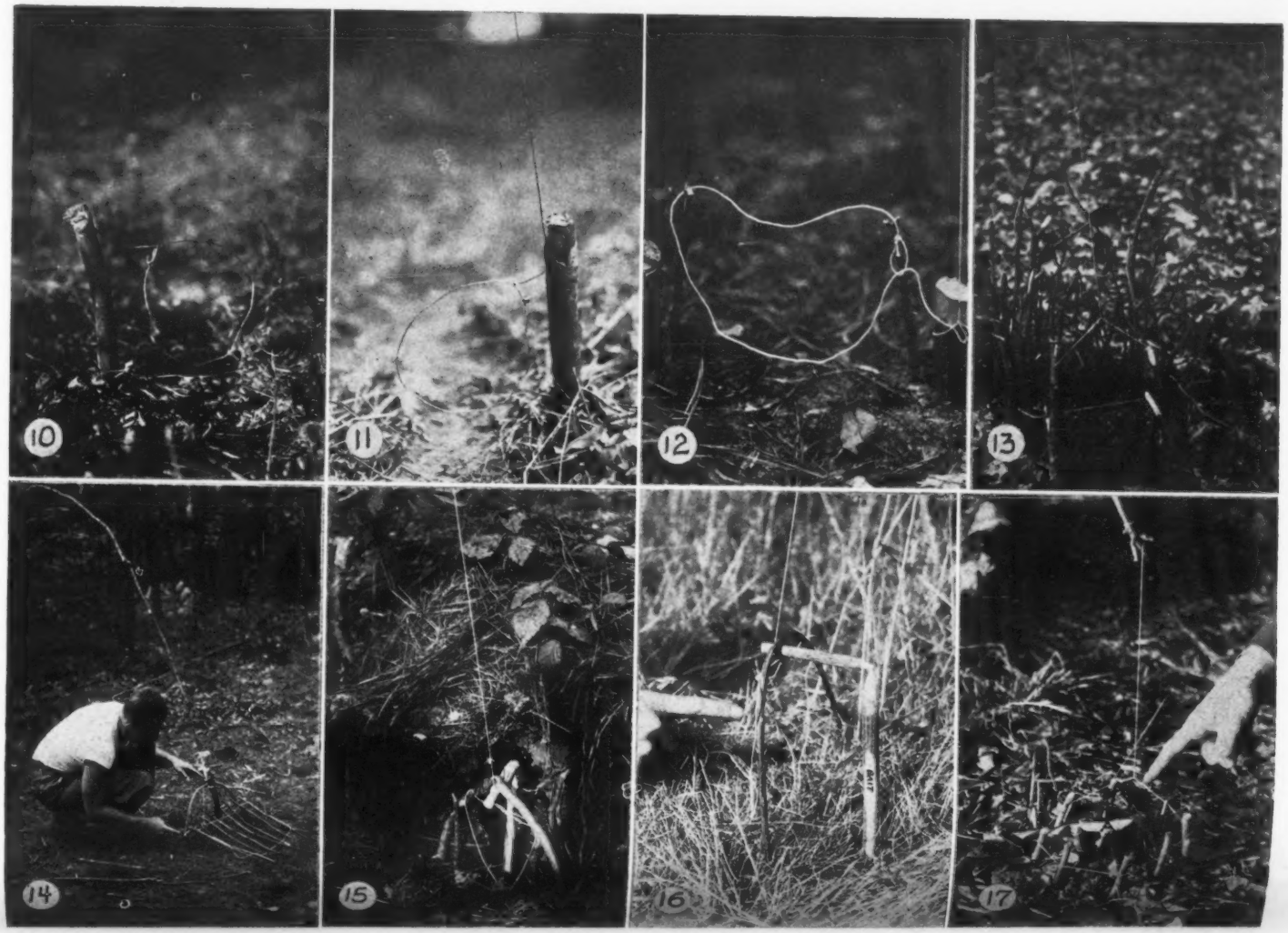
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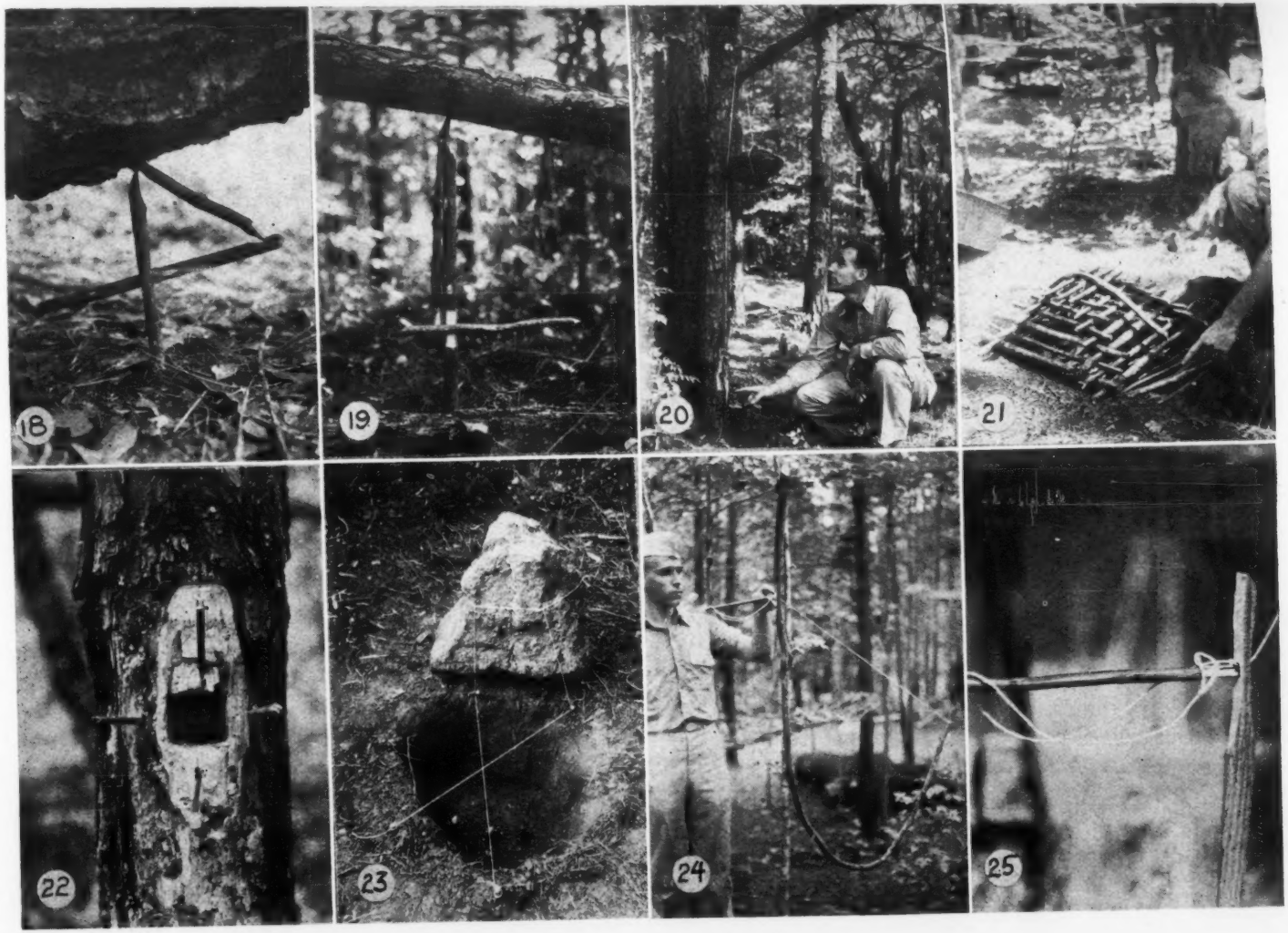
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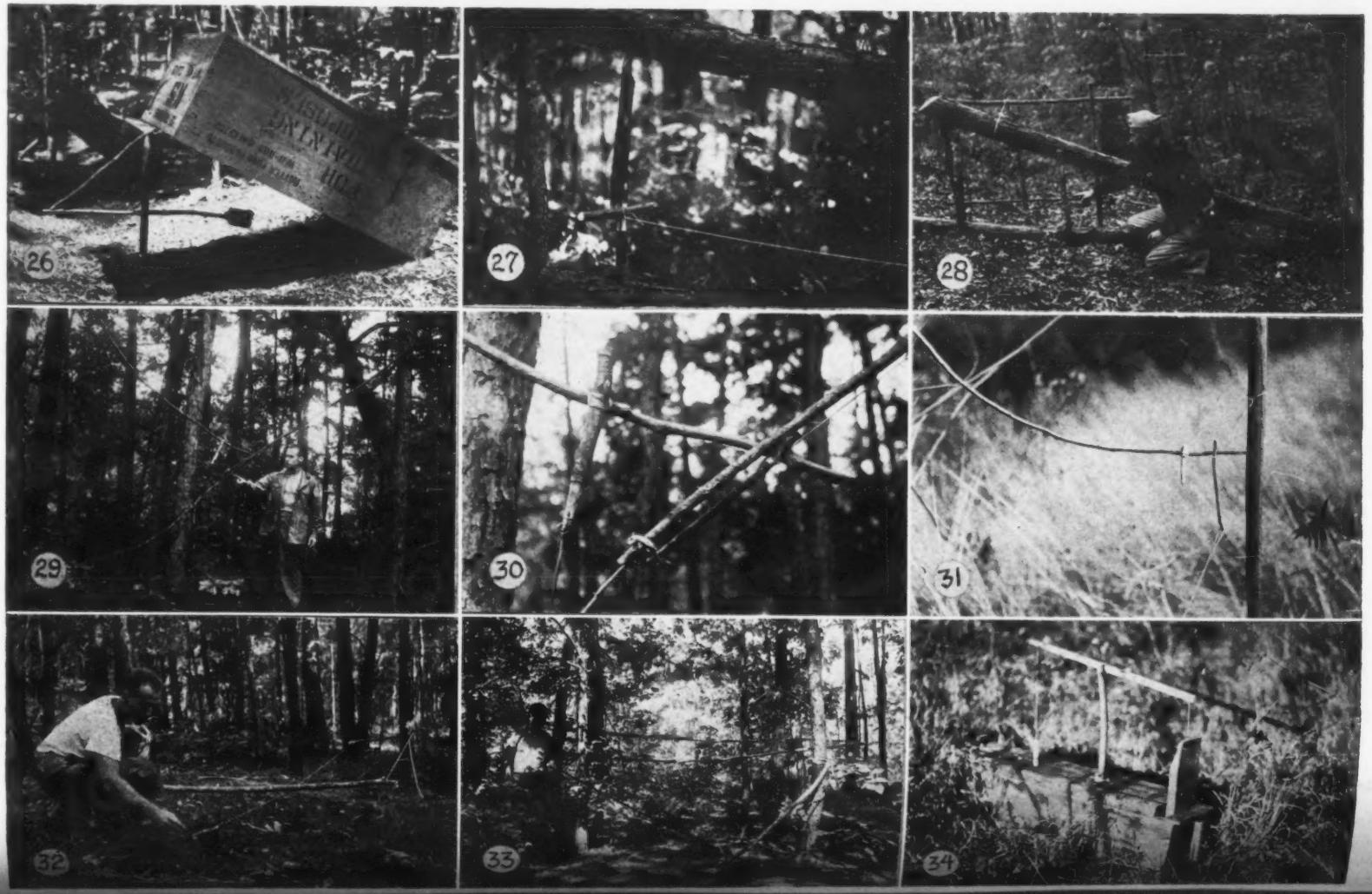
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horizontal stick is moved. The (black) wire noose hanging separately from the sapling is the only entrance when the fence of sticks or rocks is complete.

9. Letter-A snare set to catch the feet of an animal. The small pegs throw the noose upward.

13. Forked-sticks snare. The noose is pushed off the sharpened forked stakes when an animal inserts its head into the noose while attempting to reach food in the cage. Most useful where natural enclosures are available.

15. Pointed peg snare. When the baited, loose vertical stick is disturbed, its point slides off the horizontal peg tied in the line; this releases the sapling and snares the animal, which must insert its neck into the noose to reach the caged bait stick (see no. 16).

16. A rear view of the pointed peg snare (no. 15), here shown away from the enclosure that prevents access to the bait except through the noose.

17. Ring-of-pegs snare. The slanting stick (marked "A") rests in a fork and has bait hidden beneath it. Pressure on this lever, in an effort to reach the bait, springs the noose upwards and around the neck of an animal. This snare is difficult to set.

24. Bird snare. A cord passed through a square hole is held by a perch peg that fits the hole. A baited noose, on the perch, catches the bird's feet. A simple screw-eye can be substituted for the carved hole (see no. 25).

25. Details of the bird snare trigger. Recent improvements include a notched end to the perch peg so that it rests in the hole mostly on the bottom projection. An overhand knot in the tight line pulls it into position from the top and assists in setting the trigger sensitively.

DEADFALLS

A weight suspended from or held up by a sensitive trigger constitutes a deadfall. For the most part, a deadfall has the distinct advantage of requiring only materials found in the woods. Like a steel trap, however, any game caught is liable to be damaged by other animals. Deadfalls may be baited or set across runways without bait. Bait sticks, to which the food is tied securely, should project well under the weights and the triggers should be set in a sensitive manner. The weights should not be raised so high that there is delay in hitting the ground after the trigger is sprung. Several triggers for deadfalls, more complicated but not necessarily more sensitive, are illustrated by Harding (1907) and Palmer (1943).

18. Figure-4 trigger. This old reliable may be improved by making the junction between the diagonal and horizontal sticks more sensitive. A V-ledge should be cut at the end of the level bait stick and the tip of the diagonal stick should be pointed so that point rests on point. The upright is squared off, not notched, to receive the horizontal baited stick and should have an almost flat base so as to fall quickly.

19. Modified figure-4 trigger. This improved type is much more sensitive than no. 18 and easier to set.

20. Rockfall. When disturbed by an animal, the baited notched peg (lower part of photograph) slips from a ledge cut in the tree base. The rock should be placed much lower than shown; about six inches above the bait is best.

23. Pitfall. Model of a possible runway trap of this type. An animal falling through a cover of leaves would be not

only stunned, but also impaled on the sharpened stakes and crushed by the balanced rock upset as the crossed strings are struck. In some soils, a pool of water can be substituted for the sharpened stakes.

26. Figure-4 triggers set under a box and, in the background, under a rock.

27. Modified figure-4 trigger set. With a trip-string across a runway.

28. Treadle deadfall. Disturbance of the lower thin crosspiece (pointed out in the photograph) by an animal following its runway, releases the center vertical stick, and permits the log to fall.

OTHER TRAPS

21. Makeshift cage. Birds following grain bait through the tunnel fail to find their way out. The device can be also used as a drop-cage in conjunction with a figure-4 trigger.

22. Raccoon trap. Slanting thorns hold the paw of an animal reaching for bait in the hole. This trap is commonly auger-drilled several feet above the ground in a tree trunk. It is set with sharpened nails. The trap also is useful on log bridges used by game.

34. Box trap. The rear notched peg, baited inside the box, drops the door when disturbed. Large bear pens are sometimes made of logs using this principle.

TRAPS NOT ILLUSTRATED

35. Quail trap. Quail are said to be caught very simply by baiting shallow ditches dug no wider than the birds and with a dead end. Reportedly, the quail refuse to back or fly out. This device was not tested by the author.

36. Quail and other birds reportedly refuse to fly after eating grains of corn threaded on horsehairs. No opportunity was afforded to observe this method.

37. Snap-traps for animals can be made by partly splitting green logs and inserting figure-4 or other baited triggers within the cracks. Possibly, flexible branches could be made to function in the same manner by staking down one end.

38. Muskrats and other aquatic mammals can be caught, it is said, by driving long stakes into a stream bed to form a V-shaped fence leading to a corral.

39. Muskrats and other animals can be caught in barrels buried almost to the top in streambanks. Baited with corn and partly filled with water, they often are very effective.

40. Palmer (1943) describes a baited sapling snare in which a sharpened corn cob is inserted in a hole in a stake. It holds down the sapling, until disturbed, by means of a knotted string passed through the hole. A double wire noose partly completes a triangle around the bait.

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POTENTIAL VALUE OF ISLANDS FOR CONTROLLED STUDIES ON UPLAND GAME BIRDS

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A study of living organisms involves many complications not present in physics, geology, or other sciences which deal with the phenomena of inanimate matter. Factors of heredity, environment, nutrition, and pathology, all exert such a strong effect in biology that exactness in research is almost impossible. Especially in the field of wildlife investigations is it difficult to obtain precise results, primarily because the subjects must be studied under natural conditions in order for them to respond normally.

Certain kinds of fundamental research on upland game birds must be carried on under a laboratory set-up, where as many variables as possible are controlled. Experiments on metabolism, digestion, nutrition, and genetics must be conducted away from the wild environment if clear-cut information is to be obtained. Unless such knowledge gained in the laboratory can be applied directly or indirectly to the field, its value is academic rather than practical.

In the laboratory the wild subjects are confined closely in a strange environment; they generally receive unfamiliar foods in an unusual manner; and they are often exposed to bizarre treatments and much handling. In the wild, by contrast, game birds do not live in narrowly restricted areas, seldom find a mass of one kind of food in one pile, are not force-fed, usually have a selection of food that varies in more ways than can be duplicated in the laboratory, and must meet environmental vagaries and dangers throughout their lives with no assistance from man. Only by carefully controlled field studies conducted in conjunction with laboratory research can knowledge (obtained in the latter manner) be applied to game birds under natural conditions.

Field Research

Most field studies with game birds cannot be considered controlled experiments, for several major reasons, including (1) unrestricted movements of the subjects; (2) lack of control over mammalian predation; (3) unmanaged human activity; and (4) difficulty in locating check or control areas.

Under ordinary conditions, birds in the wild are at liberty to leave an area under investigation and return at will. Neighboring stock usually has easy ingress. Some coveys may be overlooked by census-takers, and others may be counted twice.

Uncontrolled predation can seriously obscure the results of a field study. For example, with other factors being comparable on two areas, two extra foxes on one can place the first area in an unfavorable light so far as game bird mortality is concerned. If a study was being conducted on such areas as to the value of certain food-plants for maintaining a quail population, how would the research worker interpret his data? The first tract of land without a doubt would have a smaller population at the

end of the experimental period. Could the food be blamed for the differential?

The human element is a problem which must be reckoned with seriously. Ordinary activities of man, such as lumbering and cropping, have a marked effect on bird life. Nests are disturbed and often destroyed accidentally. Birds are frightened from the vicinity. Adequate food and cover are diminished. As a rule, the denser the human population becomes, the smaller will be the wildlife population.

In biological research it is essential that there be a positive or negative control area, pen, or group of subjects with which others of like kind can be compared. The control should be comparable to the others in all respects except the particular factor being studied. In field research with wildlife, it usually is difficult to obtain such an ideal set-up, especially when comparisons are made of areas not completely under management of the investigating agency.

FENCED AREAS

Granting that controlled field research for evaluating the significance of any particular factor in regulating wildlife populations is difficult, what approaches offer the best possibilities for advancement of our knowledge in this subject? One outstanding qualification that constantly comes to the fore in appraising the value of methods, is that of having reasonable control or an accurate knowledge of factors operating for or against a population, without such controls being unnatural or restrictive as to the inherent nature of the creatures being studied.

With some species of wildlife, particularly small rodents, fenced areas serving as enclosures or exclosures, have been found to offer a very satisfactory degree of control. Use of enclosures for game bird studies has never been urged extensively, and there are grave doubts as to the wisdom of their use in avian research. The greater mobility and more extensive ranges of birds as compared with small mammals would require very large fenced areas with overhead covering to prevent escapes. Such areas would be exceedingly costly to establish and maintain. Control of the population would be afforded, but the fence would constitute an unnatural barrier that would prevent the creatures from behaving in a strictly normal manner. Under such an arrangement numerous other problems would exist, such as the impracticability of including woodland in the study area and the difficulty of permitting the normal effect of avian predators. As a method for controlled study, the use of enclosures does not offer much hope for further research on game bird management.

ISLANDS FOR FIELD RESEARCH

In the writer's opinion, one of the best methods for studying a game population is that used by Einarsen (N. Amer. Wildl. Conf. Trans., 7: 130-146, 1942; Murrelet, 26: 2–9, 1945) for several years. In an investigation on ring-necked pheasants, he selected Protection Island, which lies off the coast of Washington, in the Strait of Juan de Fuca. From all accounts, this island is close to an ideal outdoor laboratory for population research. The size is adequate, comprising 394 acres, much of which is arable, and the island is more than two and one-half miles from any other land, a distance greater than most upland game birds can cover in a single flight. The studies began in 1937,

only one tenant using the area (but did not reside on the island), and much of the arable land was being farmed. There were no pheasants on the island. It was visited periodically by migratory hawks and owls, but the only mammalian predators were two dogs. Two male feral cats were added to maintain predatory pressure comparable with that in the Willamette Valley, where specific knowledge of predation was needed in a game bird restoration study.

Starting with the liberation of eight ring-necked pheasants, two cocks and six hens, there was an unprecedented average annual increase in population of 277 per cent over a five-year period, then a subsequent decline to a mere remnant of the peak population. The island held the pheasants and their progeny within its boundaries, was not subjected to ingress of pheasants from surrounding land, and controlled, but did not eliminate, mammalian predation. The human element, likewise, was kept under control. Such accomplishments could not have been achieved successfully on the mainland without the establishment of the prohibitively-costly enclosures mentioned earlier. The size of Protection Island permitted growth in the pheasant population for several years without reaching saturation, yet the numbers did not increase so greatly as to hamper the investigator in his census-taking or observations.

Einarsen contributed much fundamental information from this study that is certain to provide better understanding of pheasant populations, and improvements in management. Many other worthwhile projects could be initiated if this and other islands were available strictly for biological research.

Islands would be invaluable for comparison of pen-reared and naturally-reared upland game birds. An equal number of each type of stock could be released, the pen-reared on one island and the naturally-reared on a second island. Both islands could be made comparable as to food, cover, and mammalian predation. Such a program should quickly reveal any weaknesses in the former birds, and point the way to possible corrections in propagation. In the same manner, liberations in the spring could be contrasted with those made in autumn.

Studies on the minimum and optimum requirements of game birds for food and cover could be conducted by the release on two islands of equal numbers of the same type and age of a particular species. One island could be used as a control with no special plantings of food, and the second provided with strip plantings of a suitable food, such as shrub lespedeza.

Predation also could be subjected to scientific research. With all other conditions comparable (food, cover, number and kind of subjects), a single predaceous animal could be released on one island, and none or more than one of the same kind, on the other; or a fox could be released on one and a dog on the other. On one island a fox could be released where upland game birds only were present, and another fox on a second island could be given a choice of birds and rabbits.

Thus it is evident that islands could be used successfully for studies with fur bearers and other mammals as well as upland-gamebirds. The all-round, multiple value of islands in wildlife research therefore is a possibility of considerable importance.

REGIONAL DIFFERENCES IN BREEDING POTENTIAL OF WHITE-TAILED DEER IN NEW YORK[1]

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State Conservation Department, Albany, New York

Knowledge of the breeding potential of a game species is essential to its proper management. Regional differences in productivity may demand differences in diagnosis and treatment. In the white-tailed deer (*Odocoileus virginianus*), proper management may require adjustments in laws relating to bag limits, open seasons, and legal game (buck, antlerless deer, and 1-deer laws). In cases of low fecundity, efforts to adjust the environment to increase the number of young produced may be feasible. These matters should be considered in the formulation of a policy intended to make the best possible use of game resources.

"Breeding potential" is used here to denote the potential yearly increase of young, predicated upon a composite of the available data regarding the governing factors involved. Breeding potential is not static but dynamic, and depends upon the characteristics of both the species and its environment. The ability of a species to survive and prosper in its surroundings depends upon an annual accession of young sufficient to at least equal the average annual losses over a period of years.

Breeding potential is primarily based upon two associated factors: (1) the normal litter size for the individual female (of prime importance since it is directly related to the average number of young per female of the total group) and (2) the number of sexually mature females in the breeding population, less any which may have reached senility. The actual fawn crop is governed, however, in addition to these factors, by the percentage of successfully bred females less those which die before fawning time or fail to give birth to their fawns.

For the present study, the State has been divided into two regions (Fig. 1). The northern comprises that area north of the New York Central and the Boston and Albany railroad tracks from the eastern border to Oswego County and Lake Ontario. This is also known as the Adirondack region, but its borders extend somewhat beyond the mountainous country. The remainder of the State constitutes the southern region.

This partition has been made for several reasons. The climate of the northern region sets it apart from the rest of the State. There are wide differences between the soils and vegetation of the two regions. These ecological

[1] Contribution from Pittman-Robertson Wildlife Restoration Project 1-R, New York State Conservation Department, Bureau of Game.

Members of the Bureau of Law Enforcement, and various members of the Bureau of Game assisted in collecting material for this study; Dr. Frans C. Goble helped in making autopsies; and valuable advice and criticism came from Dr. George B. Wislocki, Department of Anatomy, Harvard Medical School.

differences produce diverse environmental influences that are reflected in the habits and well-being of the deer.

The central core of the northern region, comprising about four-fifths of the area, is typical Adirondack Mountain country. The underlying geological formation is essentially granitic and the soil is exemplified by the Gloucester type, a glacial till derived principally from granite. The predominating forest is the beech, birch, maple, spruce, and balsam complex, with spruce and balsam supplanted by white pine and hemlock in the periphery. The growing season is short, 100 to 140 days, but somewhat longer near the southern border of the region. Precipitation, especially snowfall, averages heavier than in the remainder of the State.

The southern part of New York is more diversified. The underlying geological formations are mostly sedimentary, and the soils derived largely from shale, limestone, and sandstone. Throughout the major deer areas of this region, the forest is characterized by beech, birch, and maple, with pine and hemlock as the principal conifers. In many southern valleys, however, the central hardwood forest type is of oak, hickory, tulip, and poplar. Growing seasons vary from 200 to 280 days. Precipitation is sufficient for good vegetative growth, but is less than in the Adirondacks.

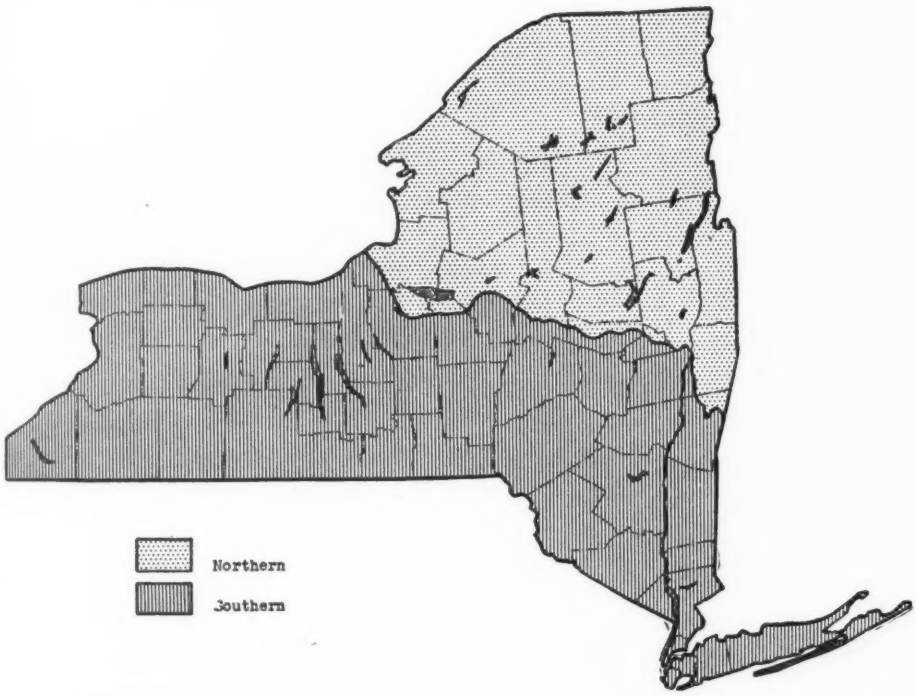

Fig. 1. Northern (dotted) and southern (lined) regions of deer range in New York.

MATERIALS AND METHODS

Only female deer were considered in appraising the breeding potential. Some specimens were sent to the pathology laboratory by the state game protectors, and others collected by the Pittman-Robertson research staff. The collections were made between January 1939 and May 1942.

All animals were autopsied and classified as adults or fawns, the latter being less than 12 months of age as established by the teeth (Cahalane 1932; McLean 1936). Embryos were recorded as to size, number, and sex.

Studies indicate the height of breeding activity to be in November, and that about two weeks elapse before the embryo becomes macroscopically visible. Hence only animals killed after January 1 each year were used, since only after that date was there reasonable assurance of distinguishing readily between pregnant and non-pregnant females. No specimens collected after May 31 were considered because most of the fawns then have been dropped and the number and sex of the young cannot be determined.

FINDINGS

The proportion of adult does pregnant in the Adirondack region was considerably below that in the southern region (Table 1), a difference found significant by the chi-square test.

The incidence of breeding among doe fawns, which at the time of conception were six to seven months of age, indicates that a high percentage of such deer are capable of breeding successfully. By contrast with the adults, there is a marked difference between fawns in the Adirondacks and those of the southern region. This difference also is significant.

As to the number of embryos per female, the ratio of singles, twins, and triplets for the northern region was approximately 8:2:1, and in the south 3:6:1. By inspection, the percentage of twins carried by southern does was considerably higher than in the northern does.

Nearly all of the doe fawns had only single embryos. In the adults, however, the difference in the average number of embryos per doe (north, 1.2; south, 1.7) proved highly significant.

Unpublished supplemental data show a lower ovulation rate, as determined from counts of corpora lutea, among northern does than those of the southern region. Furthermore, comparison of the ovulation rate with the average number of embryos per doe (Table 1) indicates that the percentage of successfully developing eggs was much higher among the southern deer. Thus the lower productivity of the northern region appears to originate from diminished ovarian function as reflected in ovulation rate, and in the lower percentage of ova developing successfully.

Table 1 shows that in the southern part of the State a higher proportion of the does were bred successfully, a larger proportion of fawns became pregnant, there was a higher incidence of twins, and a greater total number of young in uteri as compared with the northern region. The breeding potential of deer on the northern range therefore is considerably lower. All factors which might influence breeding potential should be considered, and should suggest certain means for correcting the low fertility of the Adirondack deer.

DISCUSSION

The factors which may explain the differences indicated in breeding potential probably are largely environmental. As mentioned earlier, there are marked contrasts between the geographical features of the Adirondack and southern regions. The comparatively short growing season in the north results in lesser availability of certain types of browse food, whereas succulent vegetation in the south can be had for two or three months longer. This deer exhibits marked preference for fresh growth, and since this is much richer in essential nutrients (Gordon and Sampson, 1939; Hellmers, 1940), the extent of its availability can be of considerable significance. There is also a greater variety of plant species (including agricultural crops) in the southern section. Since it has been demonstrated that differences in mineral selectivity exist among plant species (Gordon and Sampson, 1939), the greater variety of available foods in the south may enhance the opportunities of deer there to meet their specific nutritional requirements. In the north, where snow covers the ground earlier, the availability of such foods as mast or succulent ground cover is accordingly reduced.

The soil of the central Adirondacks is largely granitic in origin, and may be much lower in essential mineral components than the richer and more heterogenous soil mixtures elsewhere. The plant growth in the Adirondacks might be expected to reflect any mineral inadequacies of that soil. Theiler *et al.* (1928) found that phosphorus de-

TABLE 1.—REGIONAL DIFFERENCES IN BREEDING OF WHITE-TAILED DEER IN NEW YORK.

	Northern region	*Southern region*
Pregnancy, Adult Does		
Total examined	86	156
Pregnant, number	67	144
percentage	*77.9*	*92.3*
Difference, 14.4%; χ^2, 8.84; P, 1%		
Pregnancy, Fawns		
Total examined	72	102
Pregnant, number	3	37
percentage	*4.2*	*36.2*
Difference, 22.2%; χ^2, 22.82; P, 1%		
Embryos per Adult Doe		
One	54 (*80.6*)	48 (*33.3*)
Two	12 (*17.9*)	86 (*59.7*)
Three	1 (*1.5*)	10 (*6.9*)
Embryos per Pregnant Fawn		
One	3	35
Two	—	2
Embryos per Adult Female		
Number pregnant	67	144
Total embryos	81	250
Average per female	1.2	1.7
Embryos per Fawn Female		
Number pregnant	3	37
Total embryos	3	39
Average per female	1.0	1.0

ficiency in a grazing section of South Africa resulted in a greatly reduced calf crop. By the addition of phosphorus-rich supplements, this crop was elevated in control groups from 51 to 80 per cent. Similar areas of phosphorus deficiency exist in the United States, such as that described by Eckles (1935) for Minnesota. Mineral deficiencies involving one or more elements may exist in the Adirondacks of New York.

Recent work in the field of nutrition suggests that animals have the ability to select minerals to supplement specific dietary deficiencies (Richter 1943). Mitchell and Hosley (1936) found preferential browsing by deer on forest plots fertilized with sodium nitrate and ammonium sulfate.

Much information has been accumulated on the role of nutrition in affecting the reproductive potential of animals, from sources dealing with both domestic livestock and wild species. The practice of flushing ewes (Marshall, 1922) resulted from observations that the number of lambs produced on the range could be increased by heavy feeding of concentrates shortly before the breeding season. Clarke (1934) found that flushing leads to a higher ovulation rate when the ewes are not in a high state of nutrition. Gerstell (1942), working with white-tailed deer in Pennsylvania, concluded that on depleted ranges there is a decrease in fawn production. It is evident that both general malnutrition and a lack of essential specific nutrients may be reflected in lowering rates of reproduction. Study of the ovulation rate of Adirondack deer reveals a significantly lower average than among those from the southern part of New York. The deer from both regions are in their best physical condition during the breeding season.

The lower productivity of Adirondack deer would seem to reflect either or both of the following: (1) persistent effects from the lowered plane of winter nutrition; (2) a prevailing deficiency of one or more dietary elements essential to the highest rate of ovulation and breeding success.

Other explanations have been advanced for lowered breeding potential in the Adirondacks. One is the possibility that the sex ratio is too heavily weighted on the female side, resulting in an insufficient number of males for breeding. Such a situation might explain the relatively high percentage of adult does which pass through the breeding season without bearing fawns, but does not explain the low ovulation rate or the low embryo count.

We know that a ratio of 83 males: 100 females was found among 3,289 adult deer killed by accident in New York, but less than 10 per cent of these animals were from the Adirondack area. On the other hand, in the Moose River wintering area in the Adirondacks a sex ratio of 38:100, as determined by winter-kill, has been recorded. The latter figure agrees remarkably well with that of 40:100 estimated for the region by Townsend and Smith (1933). Leopold (1933) gives some evidence of the sex ratio of deer herds in other parts of the United States, referring primarily to mule deer, as follows: in the national forests of Montana, where a one-buck law has been in effect, a sex ratio of 63:100 was found.

On the Stanislaus Forest of Califor-

nia, where also a one-buck law has been in effect (and during the elimination of over 20,000 deer to stop foot and mouth infection), the sex ratio of the herd was 91:100. Darling (1937) gives the sex ratio of red deer [elk] in Scotland, where stag hunting is in effect, as 53:100. The concensus of opinion is that among polygamous animals such as deer, a ratio of one male to three or four females (33:100–25:100) is usually sufficient for service of all females. The available objective evidence leads the authors to believe that in the Adirondacks, the relatively high frequency of does passing through a given breeding season without being bred successfully, cannot be explained satisfactorily by postulating an inadequate number of bucks.

Study of deer ovaries from New York specimens has demonstrated that the female may experience three and possibly four estrus periods during a single breeding season. This suggests that a difference in the proportion of successfully bred females might reflect differences in the length of the breeding season in the two regions. A longer mating period might allow a doe which had passed through heat without being bred successfully or without mating an opportunity for subsequent and possibly successful matings. Studies of the breeding season, however, have indicated that only about three per cent of the does in the southern region were successfully bred outside of the limits of the Adirondack season. The authors feel, therefore, that this slight extension of the southern breeding season (due partly to the large number of fawns in the south that breed in December) could not be responsible in any large degree for the higher percentage of successfully bred southern does.

The age of sexual maturity materially affects the breeding potential. The higher percentage of fawns breeding in the south enhances the total productive female population in this area.

The fecundity of deer extends well into their later years. There are several records of twins and triplets for very old does from the southern part of New York. Their old age was deduced from the extent of tooth wear, all of the teeth being down very close to the gum line. Most of the southern does of advanced age have been found to be breeding successfully, whereas only about half of the northern animals with comparable dental wear were productive. This regional difference is of interest and, coupled with the rarity of successful mating observed among northern fawns, accents the importance of a study of differences in breeding potential between the deer of the Adirondacks and those from the southern part of New York.

SUMMARY

A higher percentage (92.3 per cent) of the adult female white-tailed deer from the southern part of New York State had been successfully bred than (79.9 per cent) among specimens from the Adirondack region.

A certain number of female fawns become sexually mature and pregnant in the autumn of the first year of life. The incidence of pregnancy in fawns from the southern region was 36.3 per cent, but only 4.2 per cent among those from the Adirondack region. The fawns bore fewer embryos per female than does more than one year of age.

The ratio of single, twin, and triplet embryos among adult females from the southern region was about 3:6:1, and for the Adirondack region 8:2:1.

Does of all ages from the southern region averaged a higher number of embryos than those from the Adirondack region.

The deer herd in the Adirondack region evidently has a lower breeding potential than that in southern New York.

Differences in the essential nutrients available to deer in the northern and southern parts of their ranges in New York probably are an important contributory factor to the disparities observed in breeding potential.

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BREEDING SEASON OF WHITE-TAILED DEER IN NEW YORK[1]

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The breeding season of white-tailed deer (*Odocoileus virginianus*) is a subject of general interest, and to the game manager knowledge of it is essential for best management of the species. Fragmentary information for the deer of New York State has been available for many years. Various competent field observers (Merriam, 1884; Seton, 1909; Newsom, 1926) have reported on autumn rutting activities and the fawning season, but their accounts were based on few first-hand observations of mating. Reasons for the paucity of data are obvious to wildlife observers who know the elusive habits of this species. The acts of mating and fawning in the wild are rarely observed, and only by direct observation and accurate reporting or by indirect experimental approach can any dependable specific knowledge of the breeding and fawning periods can be obtained.

[1] Contribution from Pittman-Robertson Wildlife Restoration Project 1-R, New York State Conservation Department, Bureau of Game.

Members of the Bureau of Law Enforcement and Bureau of Game assisted in collection of material, and others aided in the laboratory in the care of animals; Dr. Frans C. Goble gave microtechnical and autopsy aid; C. W. Severinghaus helped in the laboratory and Adirondack field work; Floyd Gates, Greenleaf T. Chase, and Cary Stott assisted in the hazardous work with controlled breeding experiments; and Dr. George B. Wislocki, Harvard Medical School gave advice and criticism in preparation of the manuscript.

Open seasons on game animals should be designed to allow the greatest "take" with the least risk of depleting the breeding stock. Some consideration of the breeding season of the species is required so that minimum interference with breeding will result from hunting activity. The number of animals actually killed and the degree of breeding success among those that remain both have an important bearing on adequate rate of population replenishment. Wise management must weigh these facts against popular forces not always directed to the best interests of our wildlife resources.

In New York, the need for information on influences affecting the breeding of deer became evident during discussion (1938) of proposed changes in the hunting season. Sufficient facts were not then available for intelligent treatment of such controversial questions as: When do the deer breed? Do deer in the Adirondacks breed earlier than do those further south? This study was undertaken to collect data on these problems. The information accumulated forms a background relating to the seasonal aspects of breeding and also to breeding potential and other fundamentals concerning the reproductive physiology of the white-tailed deer.

The period when the buck is in breeding condition is commonly termed the rutting season. It appears to be relatively continuous for individuals throughout the extent of their rut, but

interrupted occasionally by brief intervals of recuperation. The breeding condition of the does, however, is more complex. The initial activity of the sex glands of the two sexes, with approach of the breeding season, probably takes place at about the same time, but the period of estrus in the female (when the male is acceptable) is only a few hours in duration. If successful breeding does not take place, these periods recur at approximately 4-week intervals until the breeding season ends. Although the breeding activities of the two sexes are but two sides of the same coin, their operative phenomena are distinctly different; hence, for clarity, the investigative procedures and results for the two sexes are presented separately.

MATERIALS

The material from bucks comprised 151 pairs of testes, including those from 22 fawns. Whole or hog-dressed weights were obtained for most of the bucks, and estimates for the remainder. The larger part of this collection was obtained at hunting camps during the open season of 1938. Collections during other months were from deer shipped to the pathology laboratory for autopsy.

Data for females derived from 337 wild does collected during 1939–42 and 12 captive animals from the Wildlife Research Center. Most of the material from the wild was obtained through cooperation of the Bureau of Law Enforcement. Game protectors secured does shot illegally and those accidentally killed on the highway. There are 115 reproductive tracts from deer without macroscopic embryos, and 222 tracts with fetuses. Through experimental matings and later recovery of embryos, measurements were obtained on 12 sets of embryos and 3 sets of fawns at birth. Three of the experimental deer contributed more than one set of material.

THE RUTTING SEASON (MALES)

In most species of vertebrates there is an annual periodicity in breeding activity. Changes in testicular structure and function are concomitant with changes in breeding activity. The cyclic pattern of testis function among rodents is illustrated in the work of Rasmussen (1917) on the woodchuck (*Marmota*) and of Wells (1935) on the ground squirrel (*Citellus*). The testis is known to change in weight and volume and, in certain mammals, in its position in relation to the scrotum and body cavity. Trippensee (1935) used these facts in his study of the cottontail rabbit (*Sylvilagus*) and was able to demonstrate seasonal changes in testis measurements corresponding with breeding activities. The cyclic nature of the mating season of deer has been well established by field observations and by experience with captives. Recently, Wislocki (1943) has demonstrated the periodicity of gonadal function in white-tailed deer and has discussed its relationship with antler development. Knowing the periodic gross and microscopic structural changes in the testes of mammals that breed seasonally, study of the testes was needed to determine the duration and peak of the rutting season of deer in New York.

METHODS

The methods used have been described in detail in a previous paper (Cheatum and Morton, 1942), but a

brief description is in order here. The volume of each pair of testes was determined by liquid displacement in a 500 cc. graduate, reading to the nearest cubic centimeter and dividing by two for the average displacement per testis. It has been found that multiplying the volume by 1.03 will give the approximate weight in grams. Fawns were separated from animals of one year and older by their dental development (Cahalane, 1935; McLean, 1937). All deer over one year of age are classed here as adult.

TESTIS VOLUME

Testis volumes among the adult bucks ranged from 9 to 95 cc. The height of rutting activity, as indicated by these data (Table 1, Fig. 1) was reached in October and November. There was a steady decline through December and January, and from February until June the testes were within the normal size-range for the quiescent state. Few specimens were obtained during the closed season, but it appears that the cycle of growth begins in June and nears the peak by the end of September.

Testis volume for 22 buck fawns was 3 to 15 cc. By December, the volume in the larger (and presumably older) fawns began to approach the lower range of size in resting adults.

SPERMATOGENESIS

The seasonal production of spermatozoa is represented in Figure 1. Sperm were present from September through February, and were found in a single adult buck collected March 5, which had a testis volume of 25 cc. From April through June no sperm were found. One adult buck collected July 15, with a testis volume of 20 cc. had none.

TABLE 1.—VARIATION IN VOLUME OF THE TESTES AMONG WHITE-TAILED DEER IN NEW YORK.

Month	Adults			Fawns		
	Number of specimens	Volume in cc.		Number of specimens	Volume in cc.	
		Average	Extremes		Average	Extremes
May	1	12.0	12	—	—	—
June	8	13.6	9–19	—	—	—
July	1	20.0	20	—	—	—
Aug.	0	—	—	—	—	—
Sept.	3	44.6	35–53	—	—	—
Oct.	20	53.0	20–85	3	6.6	5 –10
Nov.	31	56.0	20–95	—	—	—
Dec.	38	41.5	11–65	8	10.2	3 –15
Jan.	16	24.5	12–40	—	—	—
Feb.	3	16.3	10–25	2	7.2	5.5– 9
Mar.	4	17.7	10–25	9	6.0	3.5–14
Apr.	4	15.2	10–24	—	—	—

At no time were sperm found in buck fawns. The testis growth from birth through the first year appears related to total growth of the animal, and is not subject to the seasonal factors which so greatly influence the size of testes in adults. Apparently bucks do not attain sexual maturity in their first

year, and are about 18 months old at the time of their first rutting season.

THE MATING SEASON (FEMALES)

Study of the male gonads indicated the probable duration and peak of readiness to breed on the part of the bucks. This information was of value, but the actual distribution of mating was still to be determined. The potency of the bucks during the breeding season does not necessarily indicate the actual time of mating, when the females are usually bred, or any regional differences in breeding. Data on these problems must come from a study of the female genital system. The pattern for this investigation was suggested by studies on the physiology of reproduction in sheep (Ashton, 1906; Clark, 1934; Winters and Feuffel, 1936) and the treatise by Hammond (1927) on reproduction in the cow. Study of deer ovaries might yield information on the estrus cycle and the occurrence of heat, while investigation of the embryology would make possible accurate estimation of embryo age (and thus the date of successful mating), and yield valubale information on breeding potential as appraised by embryo counts and mating failures within the breeding season.

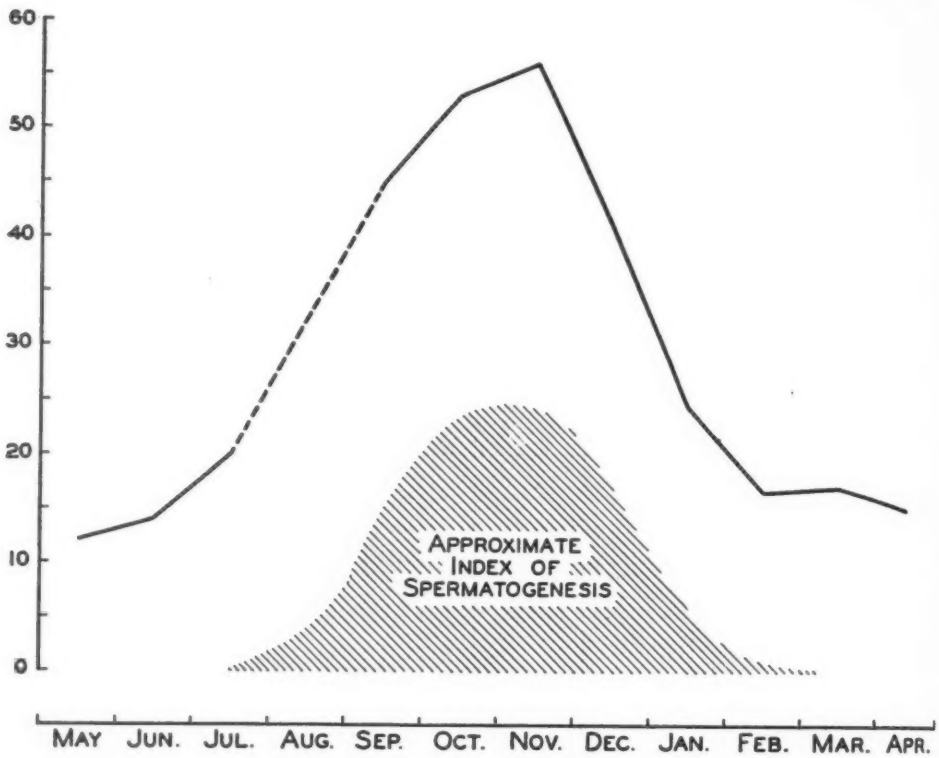

Fig. 1. White-tailed deer in New York. Variation in volume of testis (cubic centimeters) throughout the year, and approximate index of spermatogenesis.

METHODS

The procedures used have been described in detail (Cheatum and Morton, 1942), but a few essentials may be repeated. The complete reproductive system (Fig. 2A) was removed at autopsy. The external appearance of the uterus does not change appreciably until after about 20 days of gestation, hence early evidence of pregnancy must be sought by examination of the ovaries. If the doe had passed through heat (and therefore possibly bred successfully) gross examinations would reveal corpora lutea. If the latter were found, the uterus was opened and searched for small but macroscopic embryos. No study of the fertilized ova and the earliest stages of development was attempted. Owing to the delicacy of very small embryos and their membranes, the opened uterus was submerged in water and its contents washed free. A single crown-rump measurement was made on the smaller embryos (Fig. 2B), and forehead-rump and head length measurements made on larger fetuses (Fig. 2C). Data on the number, sex (if determinable) and any abnormalities of the embryos were recorded for each doe. All material was preserved in 10 per cent formalin.

From 12 experimental does bred in captivity, a normal growth curve of fetal development has been tentatively established by examining embryos at known intervals from the dates of mating. At first the does were killed, but the expense of this procedure prompted attempts at Caesarean section. The animal was placed under general anesthesia by intraperitoneal injection of sodium nembutal. The uterus was exposed through a median abdominal incision just anterior to the mamary glands and the embryos were removed through a medio-lateral incision in the anterior curvature of each

TABLE 2.—LENGTH (IN MILLIMETERS) OF EMBRYOS OF WHITE-TAILED DEER OF KNOWN AGE.[a]

Age in days	Embryos in specimen	Variability according to sex		Average
		Male	Female	
28	1	(not sexable)		8
37	2	(not sexable)		16
60	1	65	—	65
80	2	—	136	136
102	2	—	201	208
102	2	214	—	
120	2	—	273	273
131	2	300	—	296
131	1	—	288	
143	1	340	—	340
161	2	—	400	400
164	2	403	388	395
189 (birth)	2	445	441	443
200 (birth)	2	473	483	478
202 (birth)	2	439	—	439

[a] C. W. Severinghaus assisted in completing these data.

gravid horn (Fig. 2A). Fawns at birth were measured in the same manner as the fetuses. These data were then plotted (Fig. 3). The normal growth-curve thus obtained established a base for determining the breeding dates of the 222 pregnant does whose records were available. The measurement of each embryo was compared with the growth-curve and the age inferred to the nearest day. This was then subtracted from the date of the doe's death, giving the approximate date of conception.

Ovaries from deer in which no embryos were found (Table 3) were

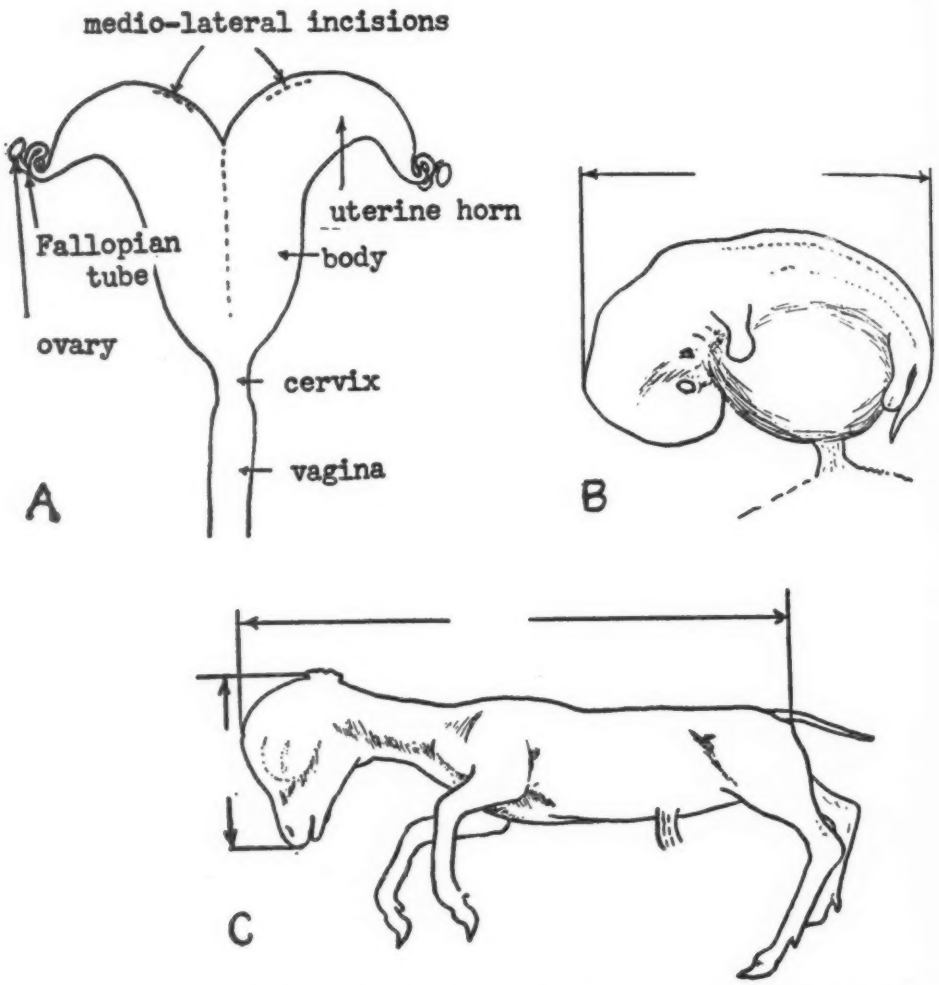

Fig. 2. A. Reproductive system of female white-tailed deer, showing position of incisions for Caesarean section. B. Crown-rump measurement of embryo. C. Forehead-rump and head measurements of fetus.

examined histologically. The presence of corpora lutea of the current breeding season was recorded as diagnostic of the passage of estrus. Up to three generations of corpora lutea within a given breeding season can be distinguished readily.

BREEDING DATES

The incidence of successful mating, as determined from embryo measurements, was highest during November (Table 4). The breeding dates for the State as a whole have been plotted by weekly intervals beginning with September 22 (Fig. 4). The peak of mating corresponded with that of the breeding condition of adult bucks as reflected by testis volume, and suggests close relationship between maximum testicu-

TABLE 3.—BREEDING CONDITION OF DOES BY EXAMINATION OF OVARIES WHEN NO EMBRYOS COULD BE FOUND.

Time of collection	Specimens examined	Specimens exhibiting corpora lutea		Incidence of recurrent estrus	
		Number	Percentage	2d	3d
Oct. 1–15	2	0	0	0	0
Oct. 16–31	4	1	*25*	0	0
Nov. 1–15	25	10	*40*	0	0
Nov. 16–30	70	56	*80*	4	1
Dec. 1–15	9	8	*89*	0	0
Dec. 16–31	5	5	*100*	0	0
Total	115	80	69	4	1

TABLE 4.—BREEDING DATES FOR WHITE-TAILED DEER IN NEW YORK, AS DETERMINED FROM EMBRYO DATA.

Conception calculated during week of	Adults						Fawns						Grand totals	
	Region				Totals		Region				Totals			
	Southern		Northern				Southern		Northern					
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Sept. 22–28	1	*0.8*	—	—	1	*0.5*	—	—	—	—	—	—	1	*0.5*
Sept. 29–Oct. 5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oct. 6–12	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oct. 13–19	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oct. 20–26	2	*1.6*	—	—	2	*1.1*	—	—	—	—	—	—	2	*0.9*
Oct. 27–Nov. 2	2	*1.6*	—	—	2	*1.1*	—	—	—	—	—	—	2	*0.9*
Nov. 3–9	5	*3.9*	8	*13.8*	13	*7.0*	—	—	—	—	—	—	13	*5.9*
Nov. 10–16	19	*14.9*	20	*34.5*	39	*21.1*	—	—	—	—	—	—	39	*17.6*
Nov. 17–23	38	*29.9*	12	*20.7*	50	*27.0*	3	*8.8*	1	*33.3*	4	*10.8*	54	*24.3*
Nov. 24–30	28	*22.0*	5	*8.6*	33	*17.8*	2	*5.9*	1	*33.3*	3	*8.1*	36	*16.2*
Dec. 1–7	11	*8.7*	4	*6.9*	15	*8.1*	6	*17.6*	—	—	6	*16.2*	21	*9.4*
Dec. 8–14	10	*7.9*	5	*8.6*	15	*8.1*	7	*20.7*	—	—	7	*18.9*	22	*9 9*
Dec. 15–21	5	*3.9*	3	*5.2*	8	*4.4*	7	*20.7*	1	*33.3*	8	*21.7*	16	*7.2*
Dec. 22–28	2	*1.6*	—	—	2	*1.1*	5	*14.7*	—	—	5	*13.5*	7	*3.1*
Dec. 29–Jan. 4	3	*2.4*	1	*1.7*	4	*2.2*	1	*2.9*	—	—	1	*2.7*	5	*2.2*
Jan. 5–11	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan. 12–18	1	*0.8*	—	—	1	*0.5*	1	*2.9*	—	—	1	*2.7*	2	*0.9*
Jan. 19–25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan. 26–Feb. 1	—	—	—	—	—	—	1	*2.9*	—	—	1	*2.7*	1	*0.5*
Feb. 2–8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb. 9–15	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb. 16–22	—	—	—	—	—	—	1	*2.9*	—	—	1	*2.7*	1	*0.5*
Total	127		58		185		34		3		37		222	

lar activity and the most frequent occurrence of estrus. The data indicate that the greatest amount of successful mating occurs between November 10 and 23.

Pregnancy among fawns has been reported earlier (Cheatum and Morton, 1942). Breeding dates in this age-class (Table 4) were somewhat later than for adults. By plotting their incidence separately, a sharp distinction between these two age-classes appears (Fig. 5). Of the doe fawns attaining sexual maturity, a majority were mated in December, approximately one month later than the majority of adult does, and during the period of decline in average testis volume.

REGIONAL DIFFERENCES

Questions have been raised concerning possible differences in the breeding season of deer in the Catskill region, the Southern Tier counties, and the

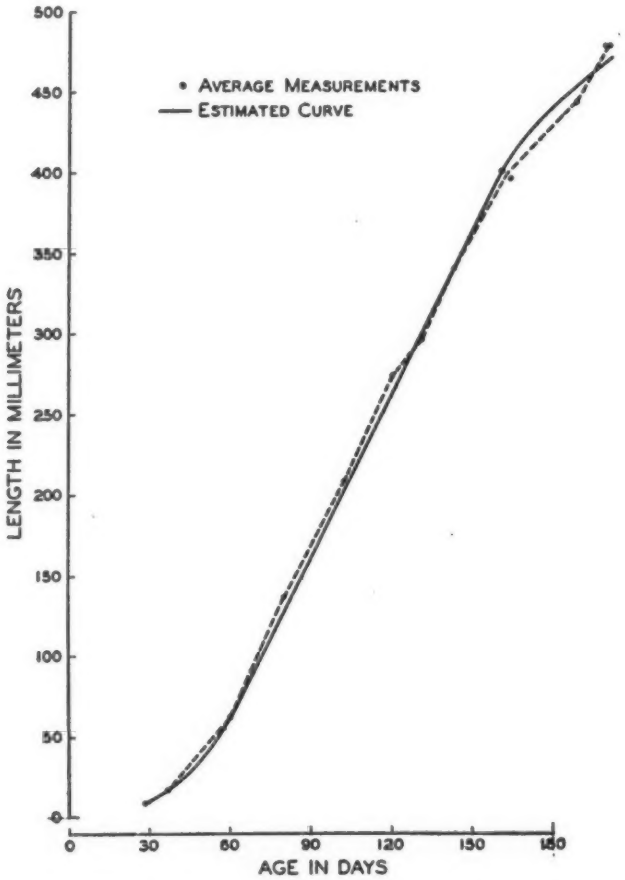

Fig. 3. White-tailed deer. Growth curve of embryos based on specimens of known age from does bred in captivity in New York State.

Adirondack region. Differences in topography and climate probably have inspired the numerous opinions encountered. The authors, however, find no difference in breeding phenomena between Catskill deer and those in the Southern Tier counties, but some differences are suggested by comparison of breeding dates of Adirondack deer with those in the southern part of New York. The State has, therefore, been divided into two regions (See Journ. Wildl. Mgt. 10: 243, 1946; fig. 1).

The inclusion of breeding fawns would alter somewhat the distribution curve of breeding frequency. Since all but three of the fawn matings were southern records, fawns have been excluded and the regional comparison has been based only on adults (Fig. 6).

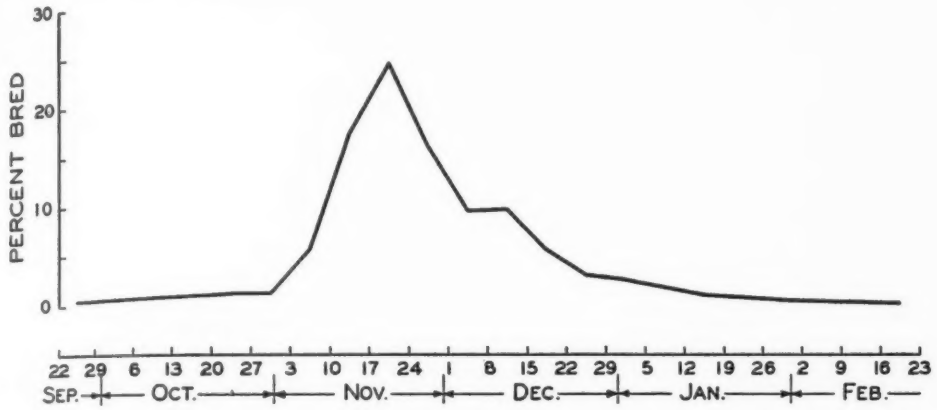

Fig. 4. White-tailed deer. Seasonal distribution of breeding in New York based on embryo development.

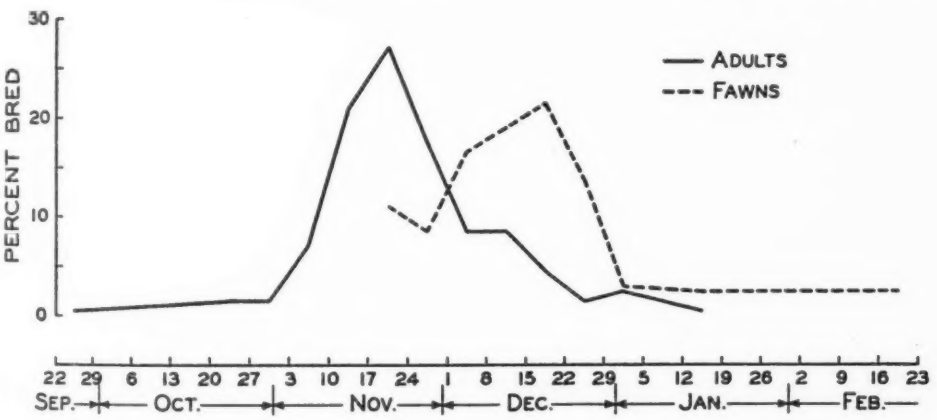

Fig. 5. White-tailed deer. Differences in breeding season of adult does and fawns in New York.

The peak of breeding among northern does was between November 10 and 16, which period included about 35 per cent of the samples from that region. During the same period, approximately 15 per cent of the southern animals were served successfully, although the peak was one week later (November 17 to 23), when nearly 30 per cent were bred.

The cumulative percentage of successful breeding for the two regions (Table 4) indicates that by November 16 about 48 per cent of northern does and 23 per cent of those in the remainder of the State had been bred. The chi-square test showed this difference to be significant.

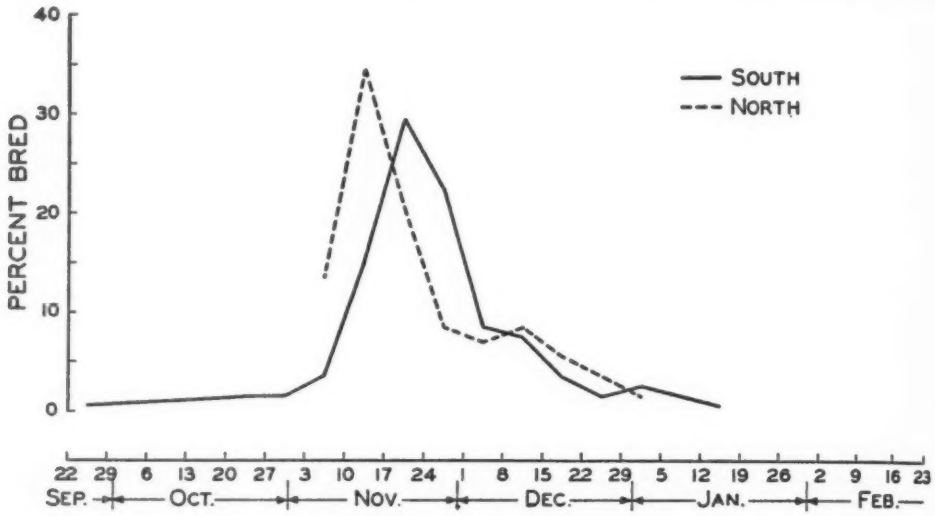

Fig. 6. White-tailed deer. Differences in breeding season in the two major regions of New York State.

BREEDING IN RELATION TO AGE

Embryo measurements were recorded from 37 pregnant fawns, 3 from the northern region and 34 from the southern (Table 4). The earliest date of breeding in this group was November 18, and the latest February 18. The bulk of breeding (about 70%) in this age-class occurred during December. Breeding data for adult does (based on a gestation period of 190 to 200 days) indicates that 65 per cent of the fawns would be dropped during the last week of May and the first two weeks of June. Since most of the doe fawns were bred in December, this would indicate the attainment of sexual maturity, culminating with estrus, at from six to seven months.

The fecundity of deer extends well into their later years of life. Several instances were found of twins and triplets born to very old does in southern New York. Their advanced age was deduced from the fact that all of the teeth were worn down close to the gum line. Most aged southern does were breeding successfully, whereas this was true of only about half of the northern

animals with comparable dental wear. This possible regional difference, coupled with the rarity of successful mating observed among northern fawns, accents the importance attached to a study of differences in breeding potential between the deer of the Adirondacks and those from the southern part of the State.

RECURRENCE OF ESTRUS

The presence of corpora lutea in an ovary is evidence that estrus (heat) has taken place and may be used to demonstrate the fact in specimens where no embryos can be found. Data for 115 such does—all collected within the span of the breeding season— are summarized in Table 3 and supplement those derived from embryo measurements. The percentage incidence of estrus was consistently higher than the cumulative percentage of successful matings during corresponding periods, as shown in Table 4. This is logical, since not all does are successfully bred during their first estrus. With the recurrence of heat approximately four weeks later, a number of previously unsuccessful does are successfully bred, thus raising the total, but some are still usually left unbred.

Of 56 does collected during the latter half of November which exhibited corpora lutea, four had passed the second period of heat and one had passed the third period. The last doe was collected on November 25, a day or two following her last heat. Since it has been demonstrated that the cycle occupies about 28 days (Cheatum and Morton, 1942) this would mean that her first estrus occurred about October 1. The breeding season may extend from October through January; hence vigorous does may come into breeding condition early and, if not successfully served, experience three or more estrus cycles during the season. Recurrent estrus may account largely for late breeding among adult does during December and January.

DISCUSSION

These data give some essential characteristics of the breeding season of white-tailed deer in New York. Adult males reach the peak of breeding condition during October and November, but some or many are capable of successful service as early as September and as late as March. Wislocki (1943) recorded the weights of testes from 13 adult bucks collected during the four seasons on Naushon Island, Massachusetts; the heaviest were taken in October and the lightest from late winter to early summer. The New York data based on volume records compare favorably with his. Wislocki's examinations revealed the presence of sperm beginning in July, with the maximum in October, and diminishing in December and January. He found none in March, May or June. The only disagreement in the New York data was the presence of some sperm in one adult buck collected March 5 and none in another collected July 15. These data would indicate spermatogenic activity over a period of eight months, but successful copulatory ability does not necessarily prevail over this entire period. Early and late records of pregnancy, however, show that some bucks are capable of breeding from September through February, and their fertility would seem to overlap by a considerable margin the estrus period of the does.

There appear to be regional differences in the incidence of mating in New York. Data from northern does include no breeding dates earlier than November 4, whereas in the material from the southern region there were three in October and one as early as September. Substantiating information on apparent absence of mating in the north prior to November comes from 124 complete female genital tracts taken October 20 to 26, 1943.[2] All were from animals of 18 months or older, but none had ovulated. Despite this delay, a significantly higher proportion of the northern animals was bred by November 16 than among the southern deer during the same segment of the breeding season. As already mentioned, there appear to be regional differences in the fecundity of old does and the frequency with which fawns attain sexual maturity and become pregnant. In both instances, the southern deer show superiority. Differences in the seasonal aspects of breeding between the two regions are indicated. These phenomena probably are related to environmental factors characterizing the Adirondack region that distinguish it from the remainder of the State as to latitude, altitude, light intensity, temperature, and other external influences.

In discussing factors controlling the periodicity of antler growth and the breeding season of deer, Wislocki (1943) has suggested that the sexual season represents a brief terminal phase of the whole hypophyseal-gonadal cycle, initiated by the increasing daylight of spring and early summer, the fall rut ensuing under conditions of diminishing light. Bissonette (1941) has observed that by keeping goats in dim light, the fall breeding season may be hastened. Assuming that this may be true also of the Cervidae, and that the terminal breeding phase is influenced by the withdrawal of light, then the earlier diminution of light northward should hasten the onset of breeding. The data presented appear to show such a trend, but with only 1.5 degrees of latitude separating the population centers of the two regions involved, doubt exists as to the significance of the difference indicated.

Concerning the possible influence of light and temperature as they may affect the onset of breeding among deer, it is of interest to compare the breeding seasons in different latitudes recorded for several species of the family Cervidae. Darling (1937) gives an account of breeding behavior in the red deer of Scotland and of the environmental factors affecting it. His study area was at approximately 58° N. The season of rut began in the latter half of September and continued through October. The reindeer in Alaska, according to Hadwen and Palmer (1922), rut from late August into October. Their study area was located near 65° N. (farther north than Darling's area), and the season of rut began earlier. The data presented here indicate that a majority of the white-tailed deer in New York (42°–44° N.) breed in November. Dixon (1934) states that the mule deer in the Yosemite Valley of California (38° N.) breed through the latter half of December and through January. Farther south, Nichol (1938) places the breeding season for the Arizona white-

[2] Material collected during antlerless deer season held in 1943; not fully analyzed and not included in the tabulations of this paper.

tailed deer between January 10 and the middle of February. Thus some relationship seemingly exists between the progressively earlier breeding of the deer and increasing latitude. The one exception for which there is authentic information is the European roe deer (*Capreolus capreolus*), which breeds in July and August, but implantation of the embryo is delayed until November (Bischoff, 1854; Ziegler, 1943).

The present study has solved some problems, contributed to the solution of others, and has pointed out others yet to be solved. There is some indication that, regardless of season, some relationship exists between the size of the testes and the weight of the animal. Among fawns this appears to be constant with skeletal growth. But even among adult deer where skeletal growth has slowed and there is a pronounced seasonal fluctuation in testis size, a relationship with body weight still occurs. The animals are in the best physical condition during the breeding season and the poorest during spring and early summer. Sexual function follows a concurrent trend but it is impossible to deduce from present data the extent to which the two are interdependent. The explanation may be found with further elucidation of the role of endocrines as regulators of bodily functions. The acquisition of body weight and increased sexual activity are probably interrelated expressions of an altered endocrine balance, the character of which may be influenced by seasonal fluctuations in stimuli from the external environment such as light, temperature and seasonal differences in food. Experimental control of these stimuli on captive deer should aid in clarifying the nature of their possible influence on the hypophyseal-gonadal cycle, and increase our understanding of the differences observed in breeding seasons.

There is a question concerning the extent to which annual variations in climatic conditions affect breeding relationships. Our data are inadequate for this, and large samples would be needed to demonstrate any small annual differences which might appear. More of value possibly could be obtained from well controlled experiments on a few animals.

Secondary sex characters of the male apparently serve as indicators of breeding condition. Any influence of age on the sexual cycle should be reflected in antler growth. Basing his assumption on the experience of several field observers, Wislocki (1943) suggested a principle governing antler growth: " . . . the more sexually mature and vigorous the animal, the earlier in a given season the antlers begin to grow. Thus the antlers of a six or eight-year-old buck put in their appearance some weeks earlier than those of the two or three-year-olds." The subsequent events of velvet shedding and casting of the antlers are similarly earlier. He interprets these observations as indicating " . . . that the more mature the animal the earlier in the season the hypophysis is activated and hence the sooner the hypophysis in turn activates the antler pedicles and the testes." Hadwen and Palmer (1922) have described age differences in the growth and casting of the antlers of reindeer in Alaska which would appear to agree with Wislocki's contention.

In our experience with captive white-

tailed deer, age differences in the seasonal growth of antlers are less pronounced than might be expected from the above observations. It is difficult to time accurately the initiation of antler growth in white-tailed deer, since the antler pedicle is obscured by long hairs at its base; the growing tips cannot be seen readily until they are about one inch long. The antlers of fawns nearly one year old tend to appear one to two weeks later than in bucks of two years or older. No consistent differences have been observed in the initiation of antler growth and subsequent phases of the breeding cycle among 2-, 3-, 5-, and 8-year bucks. Until more information is accumulated, there must be skepticism as to real differences between fully adult age groups (except senile animals) in the time at which their sexual cycles begin and end. The history of individuals would need to be followed from year to year, else there would be danger of confusing variations between individuals of the same age and those due to age difference.

The delayed appearance of antlers among yearling bucks, and the later occurrence of estrus among doe fawns breeding in their first year likely are consequences of immaturity. The mechanisms of sex, including the endocrine functions, are not yet clearly understood with respect to mature adults. Irregularities in breeding behavior and functions of the sex glands commonly seen in other animals during puberty are to be expected in deer. More and better observations are needed to determine whether there is actually a progressively earlier sexual season related to advancing age until the peak of sexual maturity is reached. Proof of this hypothesis would aid in explaining certain peculiarities as to mating incidence between regions, or groups of deer within the same region. Differences between herds in age-composition of the breeding adults would be a factor of moment in governing the inception and duration of the sexual seasons.

SUMMARY

The height of breeding condition, as evidenced by testis volume, is attained by most adult male white-tailed deer in New York by the end of the first week of November. Spermatogenesis may extend over eight months, beginning in July as found by Wislocki. Successful copulatory ability of the buck extends from September through February.

Bucks in the first year of life apparently do not attain sexual maturity in the latitude of New York State.

For New York as a whole, the peak of successful breeding among adult does is between November 10 and 23.

Differences are demonstrable between the northern (Adirondack) and southern breeding seasons. By November 16, about half of the adult northern does had bred, but only one fourth of the southern adults. The peak of breeding in the north was from November 10 to 16, and in the south from November 17 to 23. The peak of successful breeding in the Catskill region does not differ significantly from that over the remainder of the southern region.

Many doe fawns in the southern part of the State appear to attain sexual maturity in their first year and many are successfully bred, but about four weeks later than are the adult does.

Climatic factors may be responsible for regional differences in breeding seasons.

Seasonal fluctuations in body weight

and sexual activity coincide with variations in testis volume.

The influence of age in determining the annual onset of sexual activity is discussed. Wislocki (1943) has an hypothesis on antler growth: " . . . the more mature the animal the earlier in the season the hypophysis is activated and hence the sooner the hypophysis in turn activates the antler pedicles and the testes." Our observations on captives tend to support this for young deer, but limited observations on captive bucks of two years and older show no consistent differences in the initiation of antler growth and subsequent phases of the annual cycle of sexual activity which can be directly related to age. Because of the important implications of Wislocki's principle, more critical work is needed for animals two years and older.

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THE WILDLIFE SOCIETY

Report of the President

In its tenth year, 1945–46, The Wildlife Society grew in membership and financial security; its business procedures were improved and simplified; and its officials made some progress in setting up a permanent program, characterized by long-time objectives. Specific listing of activities receiving attention during the year is given in the Secretary's report.

During the year an encouragingly large number of members and nonmembers alike expressed interest in the Society's work. New memberships came in without solicitation and former members paid up voluntarily. Returning service members were most anxious to resume their professional work; and local boosting by widely scattered members brought good returns. Such spontaneity portends great vigor and capacity for growth in the Society, and offers unusual opportunity for organization work. The new Officers and Council are well aware of this opportunity.

Measures for an enlarged program in 1946–47 already in operation, are: A bigger Newsletter, to be issued quarterly as a medium for discussion, announcements, and dissemination of news pertaining to the profession; an organized membership campaign; a Foreign Membership Committee; and an Arrangements Committee, appointed in April 1946, to plan for the technical sessions of the 1947 North American Wildlife Conference program. Each of these developments is designed to meet an existing need: Only two out of every five potential Society members are enrolled; we already have members in England, Mexico, Hawaii, and the West Indies and there is opportunity to enlist more; the Secretary of the Wildlife Restoration Institute (formerly American Wildlife Institute) suggested early appointment of the 1947 program committee to permit more time and better balance in arranging for the technical sessions. The Society's relationships with the Institute, whose sponsorship we gratefully acknowledge, are now most cordial and cooperative.

In view of a good financial position, the Society may have an enlarged Journal in 1947, provided suitable papers are made available. This statement may serve as a notice that Journal copy is low and that all members having material of the necessary kind and quality are urged to prepare and submit manuscripts as soon as possible. With publication of the October 1946 issue, ten volumes of the Journal will have been published. The Editor has suggested and plans have been discussed for the preparation of a ten-year index covering this period.

During the year just closed it was repeatedly noted that one of the Society's greatest needs is a continuous, year-to-year program. To date, we have operated largely on an annual basis—new Council, new committees, and new activities each year. Such procedure is not adapted to sustained efforts and accomplishment of long-time objectives. The advantages of continuity are too obvious for comment; we merely need to recall that present sentiment for such management principles as environment

improvement or range-carrying capacity were not developed in a single year. Attainment of many Society objectives, especially those involving the slow processes of demonstration and education, may well involve years of effort. And successful attainment of such issues denotes vision, courage, unity and strength in an organization.

Progress involving these qualities stems only from capable leadership. The Society, in the judgment of its 1945–46 Council and Committee on Constitutional Revision, made an honest attempt to insure this kind of leadership, the vote on which is not known at this writing.

Growth, program and leadership are all necessary to the building of a stronger Society, a professional organization more nearly capable of guiding our professional course. Let us, therefore, regardless of personal preferences or lack of exact agreement on procedures, be of all possible aid to the new Officers and Council in the accomplishment of three main points: 1. Growth: "grass roots" support through personal boosting at home will do more to help the Society than formal campaigns: 2. Program: define and begin a sustained program of objectives designed to meet our organizational, professional, and national needs; and 3. Leadership: devise methods of insuring the most capable leadership to be found in the Society's ranks.

Activities of the Society during 1945–46 were characterized by a fine spirit of cordiality and cooperation among officers, committees, other organizations, and the membership as a whole. All have my sincere thanks.

LEE E. YEAGER, *President*

REPORT OF THE SECRETARY FOR THE YEAR ENDING MARCH 1, 1946

The last regular meeting of the Society was held at Chicago April 24, 1944. The meeting scheduled for 1945 was cancelled because of orders from the Office of Defense Transportation. Business of the Council was carried on by mail and was reported in the July 1945 issue of the Journal.

The total membership in good standing as of March 1, 1946, was 921, composed of 433 Active Members, 488 Associate Members, 5 Life Members, and 2 Honorary Members. In addition 211 libraries, institutions, and individuals subscribed to The Journal of Wildlife Management. These figures will increase as the year goes on by others paying their dues or renewing subscriptions.

Treasurer Douglas E. Wade worked closely with the Secretary. During the year we had a one-day meeting and inaugurated means to speed up payments and more efficient means of recording data on members.

As far as can be determined, 231 members now in good standing served in the armed services of World War II. It seems certain that others were in service but we have not been so informed. The Secretary has tried to indicate all who served with a flag in the annual printed list of members; he should be notified of any omissions.

The Secretary and the Treasurer have devoted much time to the men in the service, answering questions and receiving dues and memberships from all the theaters of war. Many men are now being discharged and asking to be reinstated in the Society. A large number are paying delinquent dues for the years they were in the service.

Three persons retired and resigned from the Society during the past year. A total of 33 became Active Members, 7 of these having been raised from Associate membership; and 116 were added as Associate Members. W. B. Davis, Herford N. Elliott, and Joe T. Stevens became Life Members during the year. The following were added as Active Members during 1945–46:

Ralph I. Blouch	Gustav Prevost
Bill T. Crawford	Earling R. Quortrup
Cecil F. De La Barre	Robert N. Randall
Rudolph Dieffenbach	Robert L. Rausch
R. W. Enderlin	William Rowan
John S. Gottschalk	Leslie W. Scattergood
Guy A. Greenwell	
C. R. Gutermuth	Walter P. Schaeffer
Ross Hardy	Robert H. Smith
Joseph J. Hickie	David A. Spencer
Charles E. Jackson	Richard H. Stroud
Walter Kiener	Michael J. Takos
Tracy M. Kuhn	Ernest A. Vaughn
Clifton W. Lemons	Donald B. Vogtman
Johnson A. Neff	Dwight A. Webster
Orville A. Parsons	Merrill Wood
Ralph H. Plumb, Jr.	Bruce S. Wright

There were 18 Active and 79 Associate members who were in good standing on December 31, 1944, but now are in arrears for two years.

During the past year the Secretary and Treasurer have finally arranged all "fiscal year" subscribers on a calendar year basis, the same as members. The Secretary also has succeeded in raising from Subscriber level to the Associate grade most subscribing individuals.

A number of libraries and agencies have purchased complete sets of the Journal. Scarce issues have been reprinted and at present complete sets of the Journal again are available.

The Secretary compiled the list of members in good standing for the October 1945 issue of the Journal. One charter Active Member who had previously resigned again resumed active status.

Final results on the election of officers for 1946–47 are included under the Report of the Ballot Committee.

During the past year we lost 5 members by death as follows: Active Members: Lawrence J. Palmer, Theodore H. Frison; Associate Members: Edwin C. Baetjer (killed in action), H. O. Borgfield, Jr., P. C. Walton (killed in action).

Miss Elizabeth Getz has aided your Secretary in work for the Society during the past year.

P. F. ENGLISH, *Secretary*

REPORT OF THE TREASURER FOR THE CALENDAR YEAR 1945

During the October and November, 1,400 notices for payment of 1946 dues, including some second and third delinquency notices, were sent to all members and subscribers. The payments were returned satisfactorily; on March 11, 1946, there were outstanding on 1946 payments, 29 active and 43 associate members, and 29 subscribers.

On December 31, 1945, the funds on deposit, including $500 received from five life memberships, totalled $9,002.30.

On February 14, 1946, the balance was $10,132.90. Since the latter date, it has been necessary to pay out $2,761.88 for the offset printing of certain back issues of the Journal and $686.63 for the January 1946 issue of the Journal. Despite these payments, the funds on hand on March 9, 1946, amounted to $7,079.90. All other items usually reported upon by the Treasurer are shown in the Financial Statement for the Calendar Year of 1945.

DOUGLAS E. WADE, *Treasurer*

FINANCIAL STATEMENT

For the Calendar Year 1945

Balance (December 31, 1944)	$6,005.02	
Receipts (dues, subscriptions and sale of back numbers)	6,503.93	
Total Balance and Receipts		$12,503.95[a]
Disbursements:		
General Administration		
Stationery and printing	$ 98.28	
Postage, telegrams and express	122.98	
Clerical assistance	101.25	
Bank collection charges	2.20	
Reimbursement of dues (member deceased)	4.00	
Treasurer's fidelity bond ($4,000 for 3 years)	25.00	
Editor's expenses	25.00	
Insurance on journals stored with publisher	27.33	
Publications		
Journal of Wildlife Management (4 issues)	2,807.07	
News Letter (2 issues)	225.74	
Reprints (membership lists)	23.55	
Purchase of back issues (second-hand)	29.25	
Other appropriations		
Union of American Biological Societies	15.00	
Total Disbursements		$ 3,506.65
Balance (December 31, 1945)		9,002.30[b]

Signed: Douglas E. Wade, *Treasurer*
The Wildlife Society

[a] Includes $500.00 received from five Life Members.
[b] Funds on deposit in Dartmouth National Bank, Hanover, New Hampshire.

REPORT OF THE FINANCE COMMITTEE

The Council approved the following budget for 1946.

Stationery and printing	$ 250.00
Postage, express, and telegrams	200.00
Clerical assistance	150.00
Editor's expenses	50.00
Insurance on stored Journals	15.00
Journal	3,600.00
News Letter	$ 600.00
Offset printing of back issues	2,761.88
Reprints	30.00
Purchase of second-hand Journals	50.00
Union of Biological Societies	15.00
Contingency	200.00
	$7,921.88

Balance on December 31, 1945..	$9,002.30
Estimated receipts for 1946.....	6,000.00
Total balance and receipts for 1946.....	15,002.30
Budgetary expenditures for 1946	7,921.88
Estimated balance end of 1946.	$7,080.42

It was the consensus of opinion of the Finance Committee and of the Council that the Society should operate within the approved budget for 1946. It was thought that the contingency fund of $200 will take care of any unforeseen costs.

In addition to the funds available, the Society possesses a capital asset in the stock of back issues of the Journal. These issues should be adequately protected by proper insurance.

It was the feeling of the Committee and the Council that the Finance Committee is largely an advisory group to handle (1) current problems of Society finances, and (2) to anticipate future demands.

PAUL D. DALKE
A. W. SCHORGER
TRACY I. STORER
D. E. WADE, *Chairman*

REPORT OF THE EDITOR

Volume 9 of The Journal of Wildlife Management comprised 336 pages and 15 plates, with 37 longer and 15 briefer articles, 8 reviews, and the annual reports, together with the membership list of 18 pages.

The supply of available manuscripts continues at a low level and this situation probably will be the same for a year or more. Veterans returning to wildlife work will have relatively few papers except in those instances where they are able to complete manuscripts on data gathered prior to their military service.

There still is need for marked improvement in the quality of manuscripts, despite earlier comments and the continued presence of the "suggestions for manuscripts and illustrations" on cover page 3 of the Journal. Much editorial work proves necessary before many of the papers submitted are in satisfactory condition for publication.

Consideration should be given, during the 1946 annual meeting, to the question of a general index for the Journal of Wildlife Management. The annual indexes are relatively brief, with few cross references, and to seek out particular items often is a considerable task. A general index for the 10 volumes already printed would facilitate greater use of the material in the Journal. Other societies, when confronted with this problem, commonly appoint a special committee to outline and execute the work. The nature of the material in many of the articles in our Journal is such that careful planning would be necessary to design a useful index which at the same time would not be too cumbersome.

The rapidly increasing amount of literature pertaining to wildlife, conservation, and management has brought an increasing burden on every worker in the field who endeavors to keep abreast with the accumulated knowledge pertaining to one or more animals or subjects. In other scientific fields this problem is met in part by the production of review articles which assimilate and digest long series of papers so that a reader may learn, from a rela-

tively few pages, the essential findings on a subject. Since the Society is in good financial condition and therefore able to incur further outlay for publication—if that seems desirable—consideration should be given to the possibility of soliciting such review articles. If such a program were entered upon, the most practicable means would be to designate a special committee to choose authors for the various reviews. Sufficient knowledge has accumulated to warrant such reviews on the muskrat, beaver, cottontail, red fox, white-tailed deer, racoon, mink, ruffed grouse, pheasant, bobwhite quail, turkey, and others. Likewise certain general topics such as the establishment and maintenance of various types of cover, the manipulation of marshes, the role of food patches, and kindred topics might receive attention. Such articles might be produced either as a regular part of the Journal, as a supplement to the Journal, or as a separate series sponsored by the Society.

TRACY I. STORER, *Editor*

REPORT OF THE BUSINESS MEETING OF THE COUNCIL

The Council in its annual business session on March 10, 1946 took the following action:

Clarence M. Tarzwell and Leonard W. Wing were appointed to the Membership Committee, replacing Herbert L. Stoddard and Paul L. Needham whose terms have expired.

W. L. McAtee was reappointed as trustee.

Tracy I. Storer was reappointed as Editor of the Journal of Wildlife Management.

The report of the Committee on Constitutional Revision was studied and duly approved by the Council and, in accordance with Article IX of the Constitution, will be submitted to the voting members of The Wildlife Society for action by a mail ballot.

The 1945 Council instructed the Secretary to look into the matter of reprinting scarce issues of The Journal of Wildlife Management. Scarce issues have now been reprinted. The Council feels that this is a service to the membership and makes available full sets of the Journal as well as other issues needed to complete sets at a reasonable cost.

The price of all back volumes has been set at $6.00 per volume, except as provided for veterans in the By-Laws. A member becoming delinquent more than one year will be charged at the rate of $6.00 per volume or $1.50 per number.

In view of the increased worldwide interest and activity in the wildlife field during the post-war period, the Council recommended that the President appoint a committee to study means of interesting wildlife workers in foreign lands in the Society.

The report of the finance committee was approved by the Council.

The following items considered by the Council required action of the members present at the annual meeting and are reported under the minutes of the 10th Annual Meeting: (1) The Newsletter; (2) Regions—revision of By-Laws; (3) Honorary members.

LEE E. YEAGER, *President*
P. F. ENGLISH, *Secretary*

MINUTES OF THE ANNUAL MEETING

The tenth annual meeting of the Wildlife Society was held at New York, N. Y., March 11, 1946, being called to order by President Lee E. Yeager at 7:25 P.M. All officers and about 100 members were in attendance. Reading of the minutes of the 1944 meeting was dispensed with since they were printed in the July 1944 issue of the Journal. There was no annual meeting in 1945.

After a few introductory remarks by the President, the report of the Secretary was read and approved. The reports of the Treasurer and of the Auditing Committee were read and approved.

Reports of the Regional Representatives were as follows: John Pearce gave an oral report for Region 1 and filed a written report with the Secretary. Verne Davison gave an oral report for Region 2. Warren W. Chase read the report for Region 3, which was filed with the Secretary. The Secretary read the report for Region 4 sent by Edwin R. Kalmbach, who was not able to be present. Walter P. Taylor asked Frederick M. Baumgartner to make an oral report for Region 5; a longer written report was filed with the Secretary. There was no report for Region 6. The reports for Regions 1–5 were adopted.

Clarence Cottam gave an oral report on his work as representative to the National Research Council.

The report of the business meeting of the Council was read. This is published in this issue of the Journal.

The Council recommended that the Newsletter be used as a medium for announcements, discussion of problems, and other Society matters not published in the Journal. After discussion it was moved, seconded and passed that the Newsletter be continued on the basis of 4 issues per year, staggered with the Journal issues. Charles Dambach was appointed editor for 1946–1947.

Canada was officially voted in as Region 7 of The Society. At the same time it was voted to add Puerto Rico and the Virgin Islands to Region 2, Mexico to Region 5, and Alaska and Hawaii to Region 6. Revision of the By-Laws to permit these changes was duly approved. It was also voted to change the word *two* in line 2 of By-Law 4 to *one*.

One item which received the required two-thirds vote of the 1944–45 Council, conducted by mail, was necessarily carried over to the 1946 annual business meeting. This was the unanimous election of Ernest Thompson Seton to Honorary Membership.

Ira N. Gabrielson, W. L. McAtee, and Aldo Leopold were recommended by the 1946 Council for honorary membership, and were elected by the members assembled. It was pointed out that election to Honorary Membership does not preclude in any way activity in the Society, that such members are eligible to vote, hold office, serve on committees and to participate in other ways in Society affairs.

P. F. English read a brief report of the Membership Committee.

Edward H. Graham, Chairman of the Committee on Arrangements, gave an oral report and told of the splendid cooperation of all concerned, including the cordial working arrangement with C. R. Gutermuth, Secretary of the American Wildlife Institute.

The report of the Awards Committee, submitted by the Chairman, Tracy I. Storer, was read by President Yeager.

The Committee recommended the award be given on the book, "The Ring-necked Pheasant and Its Management in North America," published by the American Wildlife Institute. The Council voted to print this notice in the Journal and not to send individual scrolls to the several authors.

The Report of the Editor was read by President Yeager and filed with the Secretary. Editor Storer pointed out the dearth of manuscripts and urged members to submit more papers for Journal use. He discussed the desirability of a 10-year index for the Journal.

Robert M. Rutherford gave an oral report for the Committee on Employment, pointing out that The Society could help in training and that the bulk of employment in the wildlife field was in connection with Pittman-Robertson work.

The report of the Finance Committee was read by Treasurer Douglas E. Wade.

The report of the Post-war Committee was read by Walter P. Taylor. This was in two parts and the second, entitled "Some Wildlife Problems that Need Attention," was not read as it is expected that it will be published in connection with Hearings of the House Committee on Wildlife. It was moved and seconded that Mr. Taylor's resolution be excluded from his report, but that it be re-written and re-submitted.

The Editor's report was changed to read that the new president appoint a committee to compile a 10-year index. A report on the Newsletter was given orally by the Editor, Charles Dambach.

It was moved and seconded that all committee reports be accepted with the changes indicated; motion passed.

The Resolutions Committee, Neil Hosley, William H. Marshall and Leo K. Couch, Chairman, submitted the following resolutions which were read by Neil W. Hosley:

1. The Wildlife Society recognizes the value accruing to its members in attendance at meetings of various scientific organizations held throughout the country, the National Research Council and the American Association for the Advancement of Science. It is urged that the regional sections of The Wildlife Society consider combining their meetings with such organizations as The International Association of Fish, Game and Conservation Commissioners, The American Fisheries Society, and the various divisions of the American Association for the Advancement of Science, whenever their national or sectional meetings are held in the respective regions of the Wildlife Society. We especially urge our regions to consider combining their meetings with those of state game administrators and sections of the Society of American Foresters.

2. In the post-war period, we foresee a time when there may be more trained biologists than available jobs. The return of our war veterans has created a critical job employment problem. The Society has a standing Committee on Employment, of which Albert M. Day is chairman. This committee keeps a list of those unemployed and refers names to prospective employers. It seems that the time has arrived for The Society to undertake a job survey of the wildlife field, listing: (a) Present jobs, regardless of whether filled or not; (b) Salaries and grades; and (c) Various categories of positions. The Committee on Employment should undertake the job survey and render a report at the next annual meeting.

3. For the last two war years, The Wildlife Society has held its prestige and scientific standing among other related scientific organizations throughout the nation, through the effective efforts of presidents O. J. Murie and Lee E. Yeager. It is the unanimous expression of the Society that official recognition be given their services by suitable inscription in the Society's records.

4. Secretary P. F. English has served the Society devotedly for 3½ years, and more than anyone else has handled and carried on Society affairs during the trying war years. He has devoted "approximately one-third time to Society work." He deserves the fullest appreciation for his services.

5. Treasurer Douglas E. Wade has served ably for three years and, with the aid of the Secretary, has dealt with many vexing details concerning Society business and finance.

6. Editor Tracy I. Storer is now entering the fifth year as Editor. The Journal speaks for itself. The work requires approximately one-fourth of his working time and is of such nature that it cannot be delegated to a secretary. He has contributed most significantly to the Society's standing and prestige. He deserves our sincerest statement of appreciation, and a letter expressing these sentiments of the Annual Meeting should be sent to the Editor.

7. Charles Dambach, Chairman of Newsletter Committee, has worked hard and faithfully on this assignment.

8. The Program Committee, particularly Edward H. Graham, deserves our thanks for a good job on assignment. Difficulties in 1946, due to uncertainties, lack of 1945 meeting, etc., were unusually great. The Committee, under Graham's leadership, worked hard for weeks in making arrangements for the present meeting.

9. The American Wildlife Institute and particularly its Secretary, C. R. "Pink" Gutermuth, has been most cordial and cooperative in planning the 1946 program. That this fine spirit continue in the future is the wish of The Society's officers and membership. The Secretary is directed to prepare suitable letters to the President and Secretary of the Institute expressing these sentiments.

10. The Hotel Pennsylvania has extended courtesies, meeting rooms, and special services and in acknowledgement of this cooperation, The Secretary is instructed to convey our appreciation to the manager.

Revised resolutions submitted by Walter P. Taylor:

"Resolved that the incoming President be directed to do all in his power to throw the influence of The Wildlife Society behind any move to unify American biological societies," in behalf of the Committee on Post-war Program.

"Resolved that the President appoint a committee with power to act, to have full charge of the program for the next meeting of The Wildlife Society and that the Committee work in close cooperation with the American Wildlife Institute."

The resolutions were filed with the Secretary.

President Yeager next presented C. R. Gutermuth, Secretary of the American Wildlife Institute, who pointed out that Edwin H. Graham, the Society's representative on the Program Committee served very effectively in making the conference program so successful. He lauded the whole-hearted cooperation from all concerned with the conference program, stating that such unity means much for conservation in this country. He stated that the conference could not cover all subjects in one program, and said that the Society should work out some plan in which items ready for consideration would be presented, to be followed in succeeding years by other subjects when matured. This plan would give every wildlife group a chance either in the current, second, or third year. Such a scheme would also give workers an opportunity to plan systematically for their place in the technical sessions. Mr. Gutermuth further recommended that we *start now* in preparing for 1947, thus insuring plenty time for attending to the many details necessary in the preparation of an outstanding program. The President, in behalf of The Society, expressed appreciation for the splendid cooperation by the American Wildlife Institute through its Secretary.

It was moved and seconded that the

President appoint a Committee on Arrangements to formulate a program to being work on the 1947 program; motion carried. The Committee is named in this issue of the Journal.

The meeting adjourned at 10:30 P.M.

P. F. ENGLISH, *Secretary*

REPORT OF BALLOT COMMITTEE

The Committee reports the following audit of the nomination and election ballots for The Wildlife Society for 1946–47:

1. *Nomination Ballots:* Total mailed to voting members, 423; returned, 159; late, 3; counted, 156 as follows: Region 1, 44; Region 2, 8; Region 3, 55; Region 4, 14; Region 5, 8; Region 6, 20 and Region 7, 10. These checked with the count of the Secretary and gave the following results:

President: 85 persons nominated; two highest, G. A. Swanson, 187; P. F. English, 64. *Vice-President:* 113 persons nominated; two highest, P. F. English, 100; D. E. Wade, 48. *Secretary:* 117 persons nominated; two highest, L. J. Bennett, 79; C. A. Dambach, 51. *Treasurer:* 135 persons nominated; two highest, P. D. Dalke, 47; N. W. Hosley, 36.

Regional Representatives: Region 1: 38 nominations; two highest, A. T. Studholme, 37; R. T. King, 24. *Region 2:* 16 nominations; two highest, V. A. Davison, 8; Richard Tift, 4. *Region 3:* 55 nominations; R. Bennitt, 18; D. L. Allen, 16. *Region 4:* 18 nominations; O. J. Murie, 9; J. R. Simon, 8. *Region 5:* 11 nominations; D. W. Lay, 8; H. L. Blakey, 6. *Region 6:* 21 nominations; P. R. Needham, 13; James W. Moffett, 12. *Region 7:* 12 nominations; I. M. Cowan, 16; A. G. Huntsman, 10.

2. *Election Ballots:* Total mailed to voting members 423; returned, 298, as follows: Region 1, 75; Region 2, 23; Region 3, 88; Region 4, 28; Region 5, 23; Region 6, 50; and Region 7, 11. Officers elected were *President,* P. F. English; *Vice-President,* Douglas E. Wade; *Secretary,* Logan J. Bennett; *Treasurer,* Paul D. Dalke.

Regional Representatives: Region 1, Allen T. Studholme; *Region 2,* Verne E. Davison; *Region 3,* Durward L. Allen; *Region 4,* Olaus J. Murie; *Region 5,* Daniel W. Lay; *Region 6,* Paul L. Needham; and *Region 7,* Ian McTaggart Cowan.

We find the above correct and final as of April 5, 1946.

GORDON L. TREMBLEY
RANDOLPH H. THOMPSON
MERRILL WOOD, *Chairman*

BRIEFER ARTICLES

AN EXPERIMENTAL FARMER-SPORTSMAN COOPERATIVE IN IOWA[1]

In 1940 two farmer-sportsman cooperative areas in southeastern Iowa, initiated and administered by a few sportsmen, were received with mixed feeling by many other sportsmen. The organization encountered no difficulty in obtaining enough cooperating farmers in each area to serve as a testing ground for future work. Farm youths, offered an active part in the work, responded so eagerly that their activities soon became the bright spot on the program.

Every year witnesses the formation of a number of cooperative organizations motivated by a desire to influence the conservation program. The plan of this organization was to lease, for a reasonable fee, the exclusive hunting privileges on privately owned farms, and to encourage farm practices beneficial to wildlife by giving the farmer pertinent technical advice, by constructing artificial shelters, and by winter feeding. A limited number of sportsmen were offered membership with the organization which entitled them, subject to the organization's rules, to hunt on the leased farms.

Farmers were visited, the program explained, and they were asked to sign a contract. These farmer contracts were largely successful when the plan was presented, through or with the aid of a local leader. Farmers gave two common objections to the cooperative: the necessary signing of a contract and the leasing of exclusive hunting privileges. The farmers considered the contract too long and complicated. Many would rather have signed none at all. Those who had confidence in the organization did not consider the signing of a contract to be a sufficient obstacle in itself to keep them from cooperating. After the first hunting season had passed, the inability of the organization to prevent trespassing, and the adverse criticism of local pressure groups of hunters, were the main reasons many farmers did not participate.

Farmers near Davenport, Rock Island, and Moline, a large metropolitan area, apparently cooperated with the organization primarily to obtain protection from troublesome hunters. In the second area, where unauthorized hunting was not so much of a problem, the farmers showed more interest in other phases of the program. All of them were interested in having their sons participate in the work. The cash returns for game did not appear to be of primary importance, but farmers generally felt that there should be some value received from hunters for game killed on the farms. Several food patches, planted as part of major cereal crops, were left unharvested to provide emergency winter food. Farmers commended the program for trying to knit a closer bond between farmers and sportsmen.

Several of the sportsmen who were offered membership in the organization worked hard to insure its success. Many of the more affluent sportsmen expressed agreement with the principles involved but did not cooperate actively. In general, the interest of sportsmen apparently rose to the height of active cooperation only for a period just preceding and during the hunting season. Local hunters outside the organization, almost without exception, were opposed to the idea. They contended that it was a step toward destroying free hunting, and that only a select few could afford membership in such an organization. The signs used in posting leased land evoked bitter criticism. Very few of the "one gallus" hunters felt that they would be benefited either directly or indirectly. The part played by farm youths, in building shelters and maintaining feed in them for wildlife, appealed to the sportsmen because of the immediate tangible results the work appeared to show.

Nine farm youths competing for cash prizes, constructed 20 brush shelters, and maintained food in them from December 20

[1] Dr. George O. Hendrickson gave technical advice and assistance, and Mr. G. Decker French, Davenport, Iowa, provided administrative aid and financial support of the project.

to March 15. The accomplishments in this work eclipsed other phases of the work. Cooperation from the boys was excellent and outside criticism was almost nonexistent. The interest by the boys in feeding and in shelter building seemed to lag somewhat early in the season, but rallied when a need arose for emergency feeding. The spirit of competition, rather than the cash return, seemed the main incentive responsible for the quality of the work. Every boy who accomplished something wanted to be recognized, but none of them wanted the competition destroyed. This interest in hunting and in learning more about wildlife was no small part in maintaining continued interest.

While many farmers believed there should be some compensation from hunters for using their farms, they were not psychologically ready to accept the idea of being relieved of the administration of hunting privileges on their lands, or of putting game production completely on a business basis. Some hunters were afraid the sportsmen's group might become powerful enough to restrict what they termed the free hunting range. Many sportsmen agreed with the basic principles of the organization but with reservations. They believed the administrative and other expenses of such an organization were so high that a majority of the hunters could not afford to be members. Farm youths enjoyed their part of the program and appreciated the opportunity to learn more about wildlife.—WILLIAM F. SIGLER, *Department of Zoology and Entomology, Iowa State College, Ames, Iowa.*

EVALUATING DUPLICATIONS IN ANALYSES OF COYOTE SCATS

In evaluating the analyses of coyote droppings, skepticism has often been expressed as to the precision of the data, particularly as to whether there is any considerable duplication in the tally of food items listed. It has been suggested that remains of the same animal, even of small mice, may easily appear in two or more scats. Admittedly this should and does occur. In the study of more than 4,000 coyote scats, over several years, I have given careful attention to this matter, and have noted what appeared to be undoubted duplications in a few cases, even with fairly small animals. But it seemed doubtful that such actual duplications of small prey would appear in any tally based on distinguishable fragments.

In the spring of 1939 I obtained from a den two coyote pups, their eyes still unopened, and raised them to maturity. In the following winter (March 1940) by artificial feeding, an attempt was made to obtain some information as to the actual number of prey animals represented in a given number of droppings. My son, Martin Murie, fed the coytes and collected the droppings. It was a casual experiment, but the results were decidedly suggestive.

On March 12 one of the coyotes, confined in a pen, ate 24 field mice (*Microtus montanus caryi*). Next day 24 more mice were fed to the same animal. Both previously and subsequently the coyotes had been fed table scraps, including such items as cooked potatoes.

On March 13, the day after the first mice were fed, six droppings were collected: March 14, ten; March 15, four; March 16, none; March 17, one; and March 18, one dropping. This was a total of 22 droppings. There was snow on the ground and possibly some droppings were overlooked, but it is believed that this number was practically all that resulted from eating the 48 mice.

Eleven droppings contained only fur, and one included some residue from kitchen scraps. Nine contained fur and a number of bones or bone fragments, or from one to four teeth, sometimes only a few fragments of such material. None contained duplicate bones to indicate more than one mouse. One contained fur and various fragments, and remains of two skulls, obviously representing two mice. One contained various fragments including three skulls, thus representing three mice. Scats containing only the residue of table scraps were ignored.

By the ordinary method of counting du-

plicated members of the body (skulls, teeth, or tails) as representing different mice, these 22 droppings contained material representing a total of 25 mice eaten, although 48 actually had been consumed.

Parts of any one mouse would certainly be distributed in more than one dropping, but it is equally reasonable to assume that each dropping contains parts of more than one mouse. Sometimes parts of several mice were present in a single dropping; but in eleven cases only fur was present, and the latter can be tallied as only one mouse in each. In nine other scats bones or teeth were present, but not in combinations that permitted tallying more than one prey animal.

From the appearance of the material, it was apparent that many of the bones had been digested. Possibly bones were digested to an unusual degree in this experiment because of the absence of mice in the diet previous to the experimental feeding; the previous food had been of entirely different nature. There is probably great variation in this respect under natural conditions, as some scats collected in the field are bristling with bones, and others are chiefly of fur.

In studying material collected in the field there is often a situation similar to that in the experiment. Often it is fairly certain that more than one mouse must be represented in a single scat, judging from the bulk of material present, yet no distinguishable relic, such as a femur or distinctive part of a skull, is duplicated; hence only one mouse may be recorded.

In the feeding experiment here described, only about half the number of mice known to have been eaten was recovered in the droppings. Hence we may safely discount the possibility of duplication in the total tally derived from study of material collected under natural conditions over a wide area.

Naturally, when bigger prey animals are concerned, such as deer or large carrion, the same animal will furnish material for a considerable number of scats. Under the usual field conditions and random collecting of scats, there probably is slight chance of duplication in the total tally of prey, up to the size of a squirrel, or even of a marmot; but the number of mice listed would likely be under the true figure.—OLAUS J. MURIE, *U. S. Fish and Wildlife Service, Jackson, Wyoming.*

UNUSUAL MUSKRAT HOUSE

The ability of the muskrat (*Ondatra z. zibethicus*) to adapt itself to changing conditions was illustrated by the use of an oil drum as a house by a pair of these animals. On February 14, 1943, in a small cattail marsh near Ithaca, New York, a 50-gallon oil drum was found on its side in 15 inches of water. Two 6×8-inch holes had previously been cut in the top; one was partly under water and the other above the surface. There were several large muskrat houses and some small feeder-houses in the surrounding marsh. An enterprising yet lethargic pair of muskrats had modified the oil drum as a home. They had utilized cattails, grasses, leaves, roots and mud to construct the inside nest and to close the hole above the water-line, but had not insulated the sides of the drum. The partly submerged hole was tightly plugged above the water line, leaving an under-water entrance hole about 4 inches wide (Pl. 20). It was obvious that a hard freeze with resulting thick ice would force them to abandon this home.

On February 16 a steel trap was placed at the underwater exit, and next day a large male muskrat was caught; two days later a female was taken. The trap was left in place for several days but no more muskrats were caught. The house then was opened and inspection showed that the water inside had frozen, indicating absence of occupants.—WILLIAM S. HEIT, 519 East Buffalo St., Ithaca, New York.

Abandoned oil drum converted into winter home by pair of muskrats in marsh near Ithaca, New York. Photographed by Wm. S. Heit, February 17, 1943.

PLANTING PRACTICE TO REDUCE CROP DAMAGE BY JACKRABBITS

On the Malheur National Wildlife Refuge, in southeastern Oregon, several hundred acres of barley and other grains are planted for winter feeding of waterfowl. The jackrabbit (*Lepus californicus*) is a constant threat to high acreage yield, especially during years when this animal is exceedingly populous.

Since barley is one of the most desirable winter food grains and also rates very high, in palatability to jackrabbits, John Scharff, the refuge superintendent, has for several years sowed a strip of rye about 16 feet wide around the edge of barley fields vulnerable to this pest. This growing barrier does a commendable job in reducing the damage since the jackrabbits eschew the rye and do not enter far enough to discover the barley.

The natural cover of sagebrush, rabbitbrush, saltbrush, and other "high desert" flora surrounding the fields seems to fulfil the cover requirements of the animal, thereby eliminating the need of the grain stand for covert.—JOHN H. LEWIS, *Department of Fish and Game Management, Oregon State College, Corvallis, Oregon.*

TEN YEARS OF ROADSIDE PHEASANT CENSUSES IN IOWA

A roadside census of Ring-necked pheasants (*Phasianus c. torquatus*) has been taken in Iowa each year since the autumn of 1936 (Bennett and Hendrickson, N. Amer. Wildl. Conf. Trans., 3: 719–723, 1938). The census is used as a means of establishing open seasons, closed seasons, bag limits, possession limits, and territorial limitations. This paper summarizes the Iowa experience with such counts for 10 years. Roadside counts made during morning and evening hours were followed by a drive or flush count of the adjacent section to determine the relationship between the birds seen on the road and the numbers found in the field. In these flush counts, the investigators were assisted by interested sportsmen, youth groups, and farmers, supervised by local conservation officers. The areas counted were carefully combed; and the relationship of birds seen on the road to the population of the adjoining field was, after being adjusted in 1941, established as follows. On flat or rolling prairie land, eight pheasants seen per mile of roadside count represented a population of one bird to the acre; four per mile represented one bird to four or five acres; one per mile represented one bird to seven or nine acres; and one-half bird per mile represented a population of one bird to 16 acres. Later it was decided arbitrarily that in hilly or timbered country, four birds per mile represented one bird to the acre; two birds per mile one bird to four or five acres; one-half bird per mile one bird to seven or nine acres; and one-quarter bird per mile one bird to 16 acres. One bird to 16 acres, or 40 birds per section, was arbitrarily set as the minimum population where shooting would be allowed. This census is taken by conservation officers early in the autumn, at the latest possible date allowing time for completion, tabulation of the figures, and official action by the Commission, before the opening date of October 28 established by law. All conservation officers start at a given time just after daylight at a previously selected point in the county, and drive for 45 minutes at 20 miles per hour on gravel or dirt side roads. At the end of 45 minutes, they return over the same road to the starting point, recording on the census sheet the number of pheasants seen on each trip. They are instructed to get some interested sportsman to accompany them so that both sides of the road and field can be watched carefully. As nearly as possible, the same roads are traveled each year. Areas covered are selected as average pheasant territory, neither the best or poorest.

Counts are made at three points in each county—northern, central, and southern—and in an east-west direction. The census reports indicate the number of cocks, number of hens, weather conditions, and other information that, in the opinion of the observer, may be of importance to the result.

Such a roadside count is well-suited to the topography and conditions in Iowa. Most of the land is flat or gently rolling prairie with

little brush or timber, making for good visibility. Interspersion of cover types, mainly tilled and untilled farm crops on nearly all farms, provides quite an even distribution of pheasants. Most of the straight section lines are marked with roads that run for miles with few or no turns.

Through the 10-year period, farmers, and other sportsmen have become accustomed to the amount of rainfall and growing conditions. In certain years a killing frost before the census flattens much of the vegetative cover, providing greater visibility than in seasons where no frost has occurred by that time. Much of the Iowa farm land is in corn, which is harvested almost entirely by mechanical corn pickers that lay the stalks flat. A good dry autumn for ripening corn will

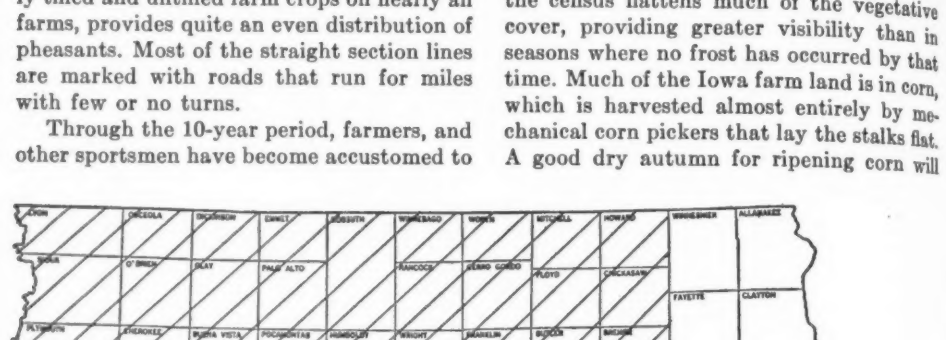

Fig. 1. Counties covered in 10 year census of ring-necked pheasants in Iowa, 1936–45.

the pheasant census. There is only limited criticism of the method of setting the season, but the method has several weak points. During these 10 years, our observations have shown that on bright dewy or frosty mornings a larger percentage of pheasants will be out on the roads or in the open than on cloudy or windy mornings, when they remain in the cover and scatter out more slowly. General weather conditions are recorded on the census sheets, but we have no reliable means to evaluate this factor. Investigations now in progress may supply data that can be treated statistically to improve the census method. Vegetative cover may vary considerably from year to year, depending on find more of the corn picked than in a wet or late season when picking may be delayed until well into the winter. The fact that the census is taken by the conservation officers makes it both convenient and economical, but most of these men lack sufficient scientific background and training to make their reports completely reliable. Each year they are given specific detailed instruction for taking the census, but we know of some instances of variations from the instructions. One officer, not finding as many birds along a road as anticipated, got out of his car, walked back, flushed birds from cover, and added them to his roadside count. Another admitted covering a territory in which he

had seen an abundance of birds all summer and early autumn, then arbitrarily added birds to his count that he did not see, and justified this by saying he knew they were there, as he had seen them on previous occasions. It is reasonable to believe that other deviations in practice have occurred, but careful questioning of officers participating in the census, makes us quite certain that this is exceptional. The instructions need further clarification, but both variations from instructions and faulty instructions add to the difficulty of accurately evaluating the figures.

In 33 counties (Fig. 1), constituting the better pheasant range, 10-year figures are given for comparison (Table 1). The counties

TABLE 1.—ROADSIDE COUNTS OF RING-NECKED PHEASANTS FOR 33 NORTH-CENTRAL COUNTIES IN IOWA, 1936–1945.

Year	*Miles Traveled*	*Total Birds Seen*	*Birds Per Mile*
1936	3,925	2,690	0.69
1937	2,957	1,444	0.49
1938	2,614	3,075	1.17
1939	2,868	7,990	2.78
1940	2,832	10,657	3.76
1941	2,876	9,888	3.44
1942	2,621	10,559	3.91
1943	2,940	7,171	2.44
1944	2,824	8,091	2.86
1945	2,850	6,763	2.37
Totals	29,307	68,328	
Ten-year average			2.33

censused were: Black Hawk, Bremer, Buena Vista, Butler, Calhoun, Cerro Gordo, Cherokee, Chickasaw, Clay, Dickinson, Emmet, Floyd, Franklin, Grundy, Hancock, Hardin, Howard, Humboldt, Ida, Kossuth, Lyon, Mitchell, O'Brien, Oscoela, Palo Alto, Plymouth, Pocahontas, Sac, Sioux, Winnebago, Woodbury, Worth, and Wright.

Limited means of checking the census are employed; these should be improved and used more extensively. Investigators in the Iowa Cooperative Wildlife Research Unit supply some data on brood counts and in general production. Conservation officers report monthly on observations made while covering their territories in regular duties, and on opinions from farmers and other sportsmen. A loose summary of reports on success and failure by hunters is gathered as an additional check. In considering this last source, it is well known that hunting success and pheasant population densities are not always very closely associated.

In 1936 and 1937 the season was closed on pheasants by the Commission. From 1938 to 1942 inclusive, it opened on November 12. During this period, the hunters generally reported good success. In 1942 the census revealed about one bird per four acres, or approximately 40 to the average 160 acre farm, in the better pheasant territory. The spring of 1942 brought an all time high in complaints of pheasant damage from farmers. During the winter of 1942–43 mass meetings were held by farmers and demands made that the season be reopened. The farmers went to their legislators with complaints and some suggested a bill be passed to allow farmers to shoot pheasants at any time on their own lands. In the spring of 1943, 11 north-central counties were opened to pheasant shooting from March 15 to 22, inclusive, with a limit of five birds of which two might be hens.

The Legislature was then in session and in April changed the opening date of the season from November 12 to October 28. The census, previously taken early in October was, of necessity, then taken during the middle of September. During none of the three subsequent years has there been a killing frost until after completion of the census. These three years were also comparatively wet, with dense vegetative growth, and roadside counts of birds per mile were above the 10-year average; but hunting success was reported poor. Observations by conservation officers during the late winter of these years tended to show a pheasant population comparable to that indicated by the roadside count. Complaints of poor hunting success were more numerous, however, than at any time during the 10-year period.

In conclusion, it seems that:

1. The present roadside pheasant census in Iowa is fairly successful.

2. The census method needs further re-

finement to provide definite means of allowing for varying weather conditions, vegetative cover, and general seasonal variations.

3. Personnel conducting the pheasant census should be better trained and more carefully instructed each year.

4. Improved means of checking the accuracy of the census should be devised.—BRUCE F. STILES and GEORGE O. HENDRICKSON, *Iowa State Conservation Commission, Des Moines, and Department of Zoology and Entomology, Iowa State College, Ames, Iowa.*

NEWS NOTES

The Society now has complete sets of The Journal for sale, and information on prices for back volumes can be supplied by the Secretary. Certain issues, of which the original stocks had been exhausted, have been reproduced by lithoprinting. Members of the Society (and libraries) owning incomplete sets will find it of advantage to obtain the necessary issues to fill out their volumes and thereby have a complete series of the technical papers, proceedings, reviews, and other papers already published in the Journal.

David B. Turner, a graduate student in the Department of Rural Education at Cornell University, is engaged in a study of education and employment in the wildlife field, embracing federal, state, and private opportunities in the United States and Canada. Funds supplied by the American Nature Association during the summer of 1945 provided for trips in the eastern states. During 1946, Mr. Turner has been awarded the first college fellowship awarded by the American Wildlife Institute (of $1,500) and will travel widely in the western and northern parts of the country to continue the study.

To expand the work of the American Wildlife Institute, The Board of Trustees recently voted to transfer the public activities and sell the physical properties of this organization to a new corporation, the Wildlife Management Institute, set up to handle a larger and broader program.

The cash surplus of the American Wildlife Institute and funds from the sale of assets, will be transferred to a Foundation that can be built into a large endowment to stabilize essential wildlife restoration and management work as existing foundations are advancing the cause of public health and education. Mr. F. C. Walcott will continue as president of this Foundation.

Dr. Ira N. Gabrielson, former Director of the U. S. Fish and Wildlife Service, is president of the Wildlife Management Institute; the other officers are: C. R. Gutermuth, Vice-President; C. Stewart Comeaux, Treasurer; and Ethel M. Quee, Secretary.

The new Institute will absorb all present activities of the former organization and will provide technical assistance to correlate and advance work of cooperating agencies in the wildlife field. The new Institute will publish books and will compile and disseminate information and educational literature advocating the adoption and use of proven wildlife practices and techniques. It will sponsor the annual North American Wildlife Conference.

The new organization will encourage the training of technical personnel and the expansion of sound research through the issuance of scholarships, fellowships, and research grants, and will occasionally conduct experimental and demonstrational projects where the needed work cannot be done by existing agencies in the areas involved. A small field staff has been employed to cooperate with other conservation agencies and associations in putting into actual operation on private or public lands effective game management practices. Upon request these men will study and analyze present programs in an attempt to suggest improvements. They will work for the abandonment of obsolete methods and the elimination of duplication of effort.

REVIEWS

Our Heritage of Wild Nature: A Plea for Organized Nature Conservation. By A. G. Tansley. Cambridge, England, Cambridge University Press; New York, The Macmillan Co. viii+74 pp., illus. 1944. $2.50.

The essence of this British book is summarized in the last chapter: "Closely interwoven with the preservation of natural beauty there are scientific and even economic interests. . . . The modern branch of biological science known as ecology, which is the study of animals and plants as they exist in nature, and of the communities they form under given conditions of climate and soil, necessarily requires the preservation of these communities as essential objects of study. Ecology is not only an important and fascinating branch of pure science, it lies at the root of all practical pursuits which involve the handling of vegetation for human purposes, notably forestry and the treatment of grassland. . . . The slow natural changes in the soil of undisturbed areas and the often rapid changes brought about by planting new kinds of trees or by initiating new types of grassland, and the repercussions of such changes on the nature and growth of the vegetation . . . are among the essential objects of such study. The 'practical man' has little time or opportunity for such purely scientific work, which lies nevertheless at the root of all his activities, so that increase of ecological knowledge has decisive effects upon his practice."

A. G. Tansley, who prepared this attractive but somewhat dry "little book" from a more detailed and technical report, *Nature Conservation and Nature Reserves* (Cambridge University Press, England, 1943), is primarily a plant ecologist; hence he stresses the beauty and character of the English countryside which is determined largely by the vegetation and topography, climate and soil. But "the claims of wild and semi-wild vegetation to a place in plans for the future are many and fundamental." This aspect of botany needs to be emphasized because there is not yet a substantial corps of plant ecologists infused into wildlife management here in North America; and here is precisely where the present book has much to offer wildlife managers in North America by way of comparison.

Tansley has avoided 'technical language,' apparently having prepared the book for popular use. He reiterates the need for a broad foundation of *natural history in the field* as basic to understanding the complex interrelationships between animals and plants and between the species of each. Yet the author may have failed to make his book on ecology sufficiently elementary, because one college dean in the eastern states, despite his splendid natural-history background, confessed that he could not understand "Our Heritage of Wild Nature." Apparently there is great need of simple "primary readers" in ecology, as well as a surge of interest in natural history. Members of the Wildlife Society should be constantly on the lookout for these "simpler" bits of literature on ecology and recommend them to college deans, wildlife administrators, students, and the lay public, if ecology is to assume the place of prominence it deserves in the management of natural resources and in education.

Tansley stresses the fundamental point that disasters of an ecological nature are also disasters aesthetically and culturally. The United States is still too robust and too young as a nation to understand the relationship between ecology and aesthetics, although a surprising number of workers in wildlife management show symptoms of such an understanding. Such an understanding of these relationships, while not yet comprehended by the lay public, affords a base from which much "decent" policy for the preservation and use of wild plants, animals, and landscape can be put into operation.—DOUGLAS E. WADE.

The Ducks Came Back. The Story of Ducks Unlimited. Farrington, S. Kip, Jr. New York, Coward-McCann, Inc. 138 pp. 1945.

In this book a persuasive writer (Mr.

Farrington) talks to an uncritical audience (the duck hunters) about an important conservation problem (the restoration of waterfowl). His argument is accompanied by soft music, in form of Lynn Bogue Hunt sketches and also excellent photos of the always-photogenic ducks.

The need for a book on the duck crop is great and real. Canada, up to a few years ago, was outdoing her teacher, the U. S., in the art of destroying duck marshes. When the drouths of the 1930's came along, there was a clear choice between restoring some marshes, or saying goodbye to duck shooting. Such work costs money, and obviously the U. S. should share the costs with Canada. Official U. S. money cannot cross the border, but private gifts can. Ducks Unlimited, a non-profit corporation, was set up as the vehicle for such gifts

It has been remarkably successful, not only in eliciting funds, but in organizing voluntary cooperation from Canadian landowners and officials. In this book. Mr. Farrington presents to the duck-hunting public the story of the origin, aims, and accomplishments to date of Ducks Unlimited.

I speak from personal knowledge when I say that we duck hunters are curious animals. In our business or professional life we are glad enough to get 6 per cent on our investments, and we feel a lofty disdain for the financial wildcatter. But in the "never-never land" of outdoor sports we insist on bonanzas. We have scant enthusiasm for any wildlife restoration scheme which recognizes difficulties, disappointments and mistakes, or which admits ignorance of wildlife management, or which calls for deferred profits and the curtailment of shooting privileges. We turn a deaf ear to the obvious fact that a century of destruction cannot be undone by wishful check-writing alone. When we went on our economic drunk, we destroyed not only the life of the land, but also something in ourselves. We have yet to learn that this can be restored only by contrition and sacrifice.

I suppose these quirks in the mental makeup of his audience convinced Mr. Farrington that duck-hunters would not invest unless offered a restoration-bonanza. Whatever the reason, this book is the prospectus of a bonanza.

Its major premise is that a large increase in ducks has already been accomplished. This is true if expressed in percentage of the 1930 flights which were near-zero. Begin low enough and almost any change short of extinction is an increase.

Mr. Farrington thinks that the work of Ducks Unlimited accounts for a large part of this increase. It does, but large is a vague word, and Canada is a large place. We should be proud that a start has been made, however small.

Mr. Farrington is sure that predators, drouths, floods, grass-fires, crows, magpies and jackfish kill more ducks than hunters do: he says that "birds shot make a very minor percentage" (of the total loss). This can be demonstrated, with some show of evidence, by assuming, as Mr. Farrington does, that every egg or duckling on the Canadian prairie is a potential greenhead dropping into the blocks at Havana, Illinois. (One could likewise demonstrate, by the same logic, that when a squirrel chews up a pine cone, he destroys a potential forest.) Egg and duckling mortality can and should be reduced, but to assume that it can or should be eliminated is, to put it mildly, a fallacy.

Moreover Mr. Farrington has selected for the attention of his audience the particular causes of mortality which Ducks Unlimited can mitigate with money: drouth losses, predation, and grass fires. He plays down botulism, which still baffles scientific research, and gun powder, the mitigation of which he regards as "straining at a gnat and swallowing a camel."

Having thus proved that further restrictions on gunpowder are quite unnecessary, Mr. Farrington shows what benefits would flow from the relaxation of those that already exist. Legalization of batteries would give useful employment to baymen (page 122), baiting would divert ducks from farm crops (page 123), live decoys would give a little shooting where none is now to be had (page 121), refuges could be converted to much-needed public shooting grounds (page 129). All of these things are true, if there are enough ducks to justify them.

Fortunately for the human race, pressure groups are never quite unanimous. No sooner

had Mr. Farrington described Ducks Unlimited as "the conservation miracle of all times," than Mr. A. C. Glassell, President of said miracle, wrote to his state chairmen: "When Ducks Unlimited was organized, we were told—and am sure we believed—that the shortage of ducks was not caused by the gun. Today and in the future the gun is going to be the mighty factor. Our duck crop will soon be exhausted unless we complete our (marsh) building program and can produce 250,000,000 ducks per year. We must do this work in a hurry before they (the ducks) are killed out."

There is no bonanza-philosophy in Mr. Glassell's statement. He sees clearly that with the return of hunters from military service, guns are increasing faster than ducks are, and that the task of building up the annual crop is tough and urgent.

Ducks Unlimited is too important an undertaking to fall victim to extravagant overclaims and outmoded exaggerations. Mr. Farrington's book should be read for what it really is: a charming fantasy. Duck hunters can afford to think that way while facing a fireside bottle, but not while facing the hard realities of 1946.

One thing can always be said to the credit of Ducks Unlimited: while other conservation organizations heaved and pulled at the statute books, it put on its hip boots and began shovelling dirt in the marsh. This is a proud record, and should not be spoiled by claims of non-existent miracles.—ALDO LEOPOLD.

The Ecology of the Prairie Chicken in Missouri. Charles W. Schwartz. Univ. of Missouri Studies, 20 (1): 1–99, 32 photos, 12 figs., 8 maps. $1.50. 1945.

This work is essentially an analytical text to the same author's fine photographic atlas on *Tympanuchus cupido americanus* (see Journ. Wildl. Mgt., 9: 86–87, 1945). The paper deals with general and local distribution in relation to soils and climate, past and present populations, the booming habit and seasons, nesting, roosting, flocking, food habits, and mortality factors.

Distribution was learned by farmer interviews and censuses of booming grounds. Current patterns of land use by man result in the existing prairie chickens being restricted mainly to medium or poor prairie soils permanently in grass, and 80 per cent of local "chicken" ranges are of 55 acres or less. In the last decade the estimated total population in Missouri has been 5,100 to 13,600 birds. The species is subject to fluctuations, possibly cyclic in character.

Most booming grounds are on ridgetops or hillsides with low or sparse cover and typically are used through a term of years if local changes in land use do not interfere. A ground may be 50 yards square to five times that area; an average of 12 (2–42) cocks inhabit a booming ground, and up to 18 (or 22) hens may visit one ground. Booming is inferred to announce the presence of males to females in the vicinity and, when they visit the ground, to attract a hen to a male's territory for mating; booming also may serve in defense of a territory from other males. Booming is most in evidence at sunrise and sunset and in April (January to June); there also is a lesser booming season in October and November.

Extreme nesting dates are April 15 and July 18, the clutch is most often 12 to 16 (8–25) eggs, and the chicks very precocial. Only 57 nests are tabulated in respect to cover, that most used being of grasses—timothy, redtop, and bluegrass. Data on food derive from the crops and gizzards of 21 birds, about 1,500 droppings, and observations on chicks hatched in captivity. The adults subsist primarily on plant materials, but take some animal food in the breeding season.

The winter bisexual flocks (up to 350 birds) break to smaller groups of separate sexes with the onset of booming. Males in summer tend toward solitary life while females attend the chicks, but by early September flocks again form.

Mowing, burning, and spring plowing are practices harmful to the birds; weather, particularly summer droughts, and illegal hunting reduce the population. Predation and disease are rated of minor import.

Recommended management procedures include a continuing closed season, and some small changes in land use practices. Restocking occasionally may be desirable, and con-

sideration must be given to local instances of crop damage by prairie chickens.

Only 5 of the 32 photographs duplicate those in the author's previous publication. Most of the maps are unsatisfactory, attempting to show too much detail at great reduction.—TRACY I. STORER.

The Ring-necked Pheasant in North America. Edited by W. L. McAtee (17 authors). Washington, D. C., American Wildlife Institute, xi+320 pp. frontisp.+31 pls. 12 figs. 1945. $3.50.

Technical and practical knowledge of game species has increased rapidly in the United States during the past 15 years, wherefore wildlife students are faced with an expanding literature and there is need for publication of general works and summaries to bring together the information already available. The present volume is timely on this score, particularly as the pheasant now is firmly established over the northern states and southern Canada, where it is much sought after by sportsmen.

The book opens with a brief historical introduction by Frederic C. Walcott and a short account of the classification and native distribution of pheasants by Jean Delacour. Then follow eight regional accounts of the bird in Pennsylvania and New Jersey, New York and New England, Ohio, Michigan, the northern prairies, the Nebraska sandhills, the intermountain irrigated region, and the Pacific northwest. There is also a chapter on pheasant propagation. The regional accounts were written by active workers who variously have made considerable first-hand studies of pheasants in their respective areas.

Discussion of the pheasant by geographic provinces is advantageous for local application of the knowledge, since practices useful in New England do not necessarily apply to Ohio or Utah. This also serves to set forth the regional differences of the species in respect to life history, food habits, and our knowledge of management procedures to date. These accounts follow somewhat of a general pattern but diverge according to the materials available at the time of writing. As a general summary the book will serve to indicate gaps in existing knowledge and point the course for further research.

Of the 79 "references" 12 are to unpublished manuscripts (theses, etc.), which are not generally accessible, and 8 more are to mimeographed or processed documents, also of limited distribution. The index (4 pp.) is far too small and utterly inadequate; about one-eighth is given to the mere list of names (text pp. 8, 9) of pheasants. Many important topical and subject items are without index entries. There are only 7 entries on cover, and none for environmental improvement, sportsmen-farmer relationships, or similar important topics. If the book dealt with pheasants over all of the continent in one running account, all materials on a topic would have been brought together and could be found readily; but the index is of no help to a reader seeking the various regional contributions on a subject—he must hunt them out.

The style is easy and pleasant and the nice physical format continues that of previous volumes published by the Institute. The book is replete with factual detail on a miscellany of topics such as effects of refuges and soil fertility, restocking, food, winter killing, various types of cover needed, effects of hunting, brood production, etc. For anyone interested in pheasants this volume is required reading.—TRACY I. STORER.